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Source Separation Collection and Processing Equipment

Resource Planning Associates, Inc.
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Final Report

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Final report of EPA sponsored study of collection, receiving, conveying and processing equipment to be used in a source separation program. This report provides detailed descriptions of equipment, examples of its uses, including cities where the equipment is used, and specific recommendations on equipment design and use. The report also summarizes the research effort behind the user's guide and contains copies of important research tools. The report is a detailed version of the EPA publication Source Separation Collection and Processing Equipment: A Users Guide. (SW-842)

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SOURCE SEPARATION COLLECTION AND PROCESSING EQUIPMENT

Final Report

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Contents

CHAPTER	PAGE	TITLE
INTRODUCTION		
CHAPTER 1	1.1	HOUSEHOLD SEPARATION UNITS
CHAPTER 2	2.1	COLLECTION EQUIPMENT
CHAPTER 3	3.1	STORAGE EQUIPMENT
CHAPTER 4	4.1	RECEIVING EQUIPMENT
CHAPTER 5	5.1	CONVEYANCE EQUIPMENT
CHAPTER 6	6.1	PROCESSING EQUIPMENT
APPENDIX A	A.1	Summary of Research Methodology and Assumptions
APPENDIX B	A.2	Recommendations for Procurement of Source-Separation Collection and Processing Equipment
Exhibit 1	1.3	Special Containers: Program Data Summary
Exhibit 2	2.3	Compactor Trucks: Program Data Summary
Exhibit 3	2.5	Other Adapted Vehicles: Program Data Summary

CONTENTS

Exhibit 4	2.8	Racks: Program Data Summary
Exhibit 5	2.10	Single-Material Trailers: Program Data Summary
Exhibit 6	2.12	Multimaterial Trailers: Program Data Summary
Exhibit 7	2.15	Compartmentalized Dump Trucks: Program Data Summary
Exhibit 8	2.17	Trucks With Bins: Program Data Summary
Exhibit 9	3.2	Storage Equipment: Data Summary
Exhibit 10	3.3	Roll-off Containers: Data Summary
Exhibit 11	3.4	Capacity of Transfer Trailers
Exhibit 12	4.2	Receiving Equipment: Data Summary
Exhibit 13	5.2	Conveyance Equipment: Data Summary
Exhibit 14	6.2	Glass Crushers: Program Data Summary
Exhibit 15	6.3	Glass Crushers: Manufacturer Data Summary
Exhibit 16	6.4	Characteristics of Paper Balers: Manufacturer Data Summary and Program Data Summary
Exhibit 17	6.7	Characteristics of Magnetic Separators: Manufacturer Data Summary and Program Data Summary
Exhibit 18	6.9	Characteristics of Car Flatteners: Manufacturer Data Summary and Program Data Summary
Exhibit 19	6.10	Characteristics of Can Shredders: Manufacturer Data Summary and Program Data Summary

CONTENTS

Exhibit 20	6.13	Scales: Program Data Summary
Exhibit 21	A.3	Letter to Associations and Solid Waste Publications
Exhibit 22	A.4	Solid Waste Associations and Publications Contacted
Exhibit 23	A.5	Sample Press Release
Exhibit 24	A.6	Press Releases
Exhibit 25	A.9	Source Separation Systems
Exhibit 26	A.10	Sites Visited
Exhibit 27	A.11	Interview Guide for Communities
Exhibit 28	A.12	Interview Guide for Equipment Manufacturers
Exhibit 29	A.15	Communities Collecting 50 Tons or More of Source-Separated Materials Per Month
Exhibit 30	A.16	Communities Contacted Concerning Site Visits
Exhibit 31	A.20	Interview Guide
Exhibit 32	B.2	Source Separation Program Development
Exhibit 33	B.7	Procurement Lead-time

Introduction

In recent years, numerous municipalities have undertaken programs to collect and recycle used cans, glass, and newspaper. Communities generate revenues by selling recycled materials and save on waste disposal costs by diverting the materials from overcrowded landfills.

Because they have proven to be attractive alternatives to waste disposal, recycling programs are growing in number. A recent U.S. Environmental Protection Agency (EPA) study indicates that the number of separate-collection programs has increased one-hundredfold, from 2 to 200, in the last decade. In addition, there are now over 2,000 recycling centers in the United States.

Despite the growing interest in recycling, local decision-makers have had to implement most programs with minimal guidance or assistance. Without adequate information, many officials have selected or designed inadequate or excessively expensive equipment to collect, store, convey, and process recyclables. The efforts of local officials to develop workable source-separation collection systems also have been hampered by the lack of a competitive equipment industry. Most recycling programs purchase their equipment from small collection and processing equipment manufacturers. Because of the low sales volume, varying equipment needs, and uneven geographic distribution of the recycling market, a more sophisticated and diverse industry has not been established.

In an effort to promote recycling, EPA has developed descriptive reports on source-separation collection programs. In addition, the agency has undertaken equipment research, concentrating on mixed-waste collection equipment and large-scale mixed-waste processing facilities.

This project is the first to address the use of collection and processing equipment in recycling programs. Two documents have been prepared in this project: an equipment

guide and a final report. By providing analyses and evaluation of equipment, EPA hopes to assist local decision-makers in selecting equipment and expand their involvement in equipment commercialization.

Source-Separation Collection and Processing Equipment: A User's Guide

The guide (U.S. EPA Solid Waste Publication SW-842) was developed to assist local governments and private collection companies in selecting source-separation collection systems and equipment components best suited to their specific needs. As a planning aid, the guide's primary audience is municipal solid waste officials, public works directors, and officials of private sanitation companies. Other users of the guide might include equipment manufacturers, engineering design firms, and the interested public.

The guide is the product of an extensive compilation of data on equipment used in source-separation collection and processing systems in the United States. The guide presents and analyzes each piece of equipment in terms of its advantages, disadvantages, and design issues.

Project Report

This project report provides more detailed descriptions of equipment and specific recommendations on equipment design and use. The report also summarizes the research effort behind the user's guide and contains copies of important research tools.

1 HOUSEHOLD SEPARATION UNITS

Prior to collection, residents participating in source-separation programs separate their recyclables from other waste. They store the materials in common household containers such as grocery bags and trash cans or in containers designed especially for recyclable materials.

COMMON HOUSEHOLD CONTAINERS

Common household containers such as cardboard boxes or grocery bags help keep recyclables separated from refuse and make collection at the curb easier. They do not keep materials dry when placed at the curb during rain or snow, however. Common containers generally are available to residents free of cost. However, they do not particularly encourage householders to recycle. Collection programs that rely on common containers place a slight burden on residents by requiring them to provide the containers. Paper grocery bags can be used for newsprint collection as an alternative to tying bundled newspapers with string. Paper bags are not recommended for glass and can collection because they are not strong enough for glass and fall apart when wet. Programs considering the use of paper bags should determine whether their markets will accept bagged materials.

SPECIAL MARKERS

Special markers are distributed by some communities for placement on common household containers such as trash cans and buckets. Markers promote recycling programs and assist residents and collection crews in identifying recyclable containers. They are fairly inexpensive to produce and, because they serve as a reminder to recycle, can result in increased participation.

SPECIAL CONTAINERS

Special containers are provided or made available by several separate-collection programs (see Exhibit 1). These containers serve to maintain recyclables in marketable form (e.g., dry, separate from contaminant), to promote the collection program, to control littering, and to reduce inconvenience to the householder and collection crew. Four kinds of special units commonly used in source-separation programs are:

- Basket
- Onion Sack
- Bucket
- Stacking pan cart.

Basket

Open-ended baskets, similar to household wastebaskets, have been used successfully in University City, Missouri, to separate newspaper from other refuse.

Baskets can be designed or purchased in a variety of capacities, depending on the amount of materials expected. The unit used in University City is approximately 19" x 20" x 6", costs $7.00 and holds a two-week supply (22 lbs) of newspaper. The units have an estimated effective life of 10 years and a replacement factor of about 5 percent per year.

The University City basket, constructed of U.V. stabilized polyethylene, was designed with one side extending beyond the other; when the unit is placed correctly at the curb, the longer side serves to protect the materials from the weather and guards papers from blowing away.

The units in University City are easy for collectors to spot: they are bright yellow and display the name of the program in bold letters. Because they are lightweight and have molded round edges and smooth surfaces, the baskets are easily handled by householders and collectors.

Exhibit 1

Special Containers: Program Data Summary

	Location			
	University City, MO Basket	**Seattle, WA** Onion Sack	**El Cerrito, CA** Bucket	**Santa Rosa, CA** Stacking Pan Cart
Height	14"-19"	32"	N/A	12" (each pan)
Length	18"-20"	18"	N/A	12"
Width	6"	N/A	N/A	18"
Weight	3 lbs	2 oz.	0.67 cu. ft.	N/A
Volume	1.0 cu. ft.	1.5 cu. ft.	5 lbs. metals	4.5 cu. ft.
Capacity	20 lbs. newspaper	15-20 lbs. glass 8-10 lbs. mixed metals	10-15 lbs glass	30 lbs. newspaper, 10 lbs. metals 15-20 lbs. glass
Material	High-density U.V. stabilized poly-ethelene	Plastic mesh	Plastic	Wood, polyethelene
Purchase lead-time	8 months	1 month	2 months	3 months
Residences served	10,000	10,000	2,300	1,600
Percent of time in use[a]	60%	98%	100%	99%
Provision system	Provided free of charge	Provided free of charge	Sold to individual	Cost shared by municipality and individual
Ownership	Municipality	Contractor	Individual	Individual
Frequency of collection	Bi-monthly	Monthly	Weekly	Weekly
Participation rate[b]	60%	34%	50%	76%
Include logos	Yes	Yes	Yes	Yes
Years in use	6 years	2 years	1 year	1 year
Purchase cost[c]	$6.95	$0.30	$3.25	$14.62
Estimated life	10 years	5 years	10 years	10 years
Replacement factor	5%	50%	10%	5%

SOURCE: Resource Planning Associates, Inc.

a Percent of participating residences using containers.

b Average participation rate of residences in the source separation program.

c Purchased for source separation program.

Onion Sack

Onion sacks are the most cost-effective of the special units. Onion sacks are inexpensive (they cost approximately $0.30 each) and have an estimated life of 5 years. The 18" x 32" units contain between 8 and 10 lbs of metals or between 15 and 20 lbs of glass. The SORT recycling program has to replace about half its sacks each year.

The sacks can be hung under kitchen sinks, in cabinets, or in closets to facilitate handling by householders. Units with drawstrings are inefficient, however; they must be untied each time they are loaded or unloaded. Sacks containing a full load of newspaper (35 lbs) may be too heavy for some residents to carry to the curb and may also create a strain for collectors. Sacks are made of open mesh because mesh is lightweight and sanitary. As a result, the sacks are susceptible to moisture and dirt, which contaminate the materials. To enhance the sack's visibility, a sticker or label with the name of the program on it may be placed on the sacks, along with a bright-colored mesh.

Bucket

Residents of some communities use plastic 5-gallon buckets, similar to paint buckets, to store recyclables. The buckets, which provide adequate storage for a weekly collection of cans or glass, contain up to 5 lbs of metal or between 10 and 15 lbs of glass. Buckets have a unit cost of $3.25 and have a useful life of about 10 years. An estimated replacement factor for buckets is about 10 percent per year.

The handle on the bucket facilitates moving the bucket to the curb and unloading the materials into the collection truck. Because it has an open top, however, the bucket does not keep materials dry or free of contaminants.

Stacking Pan Cart

A three-pan stacking unit with wheels can store up to three different materials. At a purchase cost of $14.60, the unit has the capacity to hold 10 lbs of newspaper, 10 lbs of metals, and 15 lbs of glass. The cart has a

useful life of 10 years and a 5-percent replacement rate can be expected.

Sufficient space (approximately 5 square feet) must be allocated to store the unit in the home. Handling is somewhat cumbersome for both the resident and the collector; the inconvenience adds to the time required to load and unload the pans.

Because of their size, shape, and color, the units are very visible to collection crews. The pans effectively maintain the quality of recyclables after they have been placed at the curb. Placing the newspaper pan below another interlocking container keeps the paper dry.

DESIGN RECOMMENDATIONS

Stickers should be self-adhesive and applicable to different surfaces such as metal, plastic, or fiber. They should be a minimum of 3" x 9" in size and of a bright color. If possible, the color should be the same as that used on waste collection vehicles, recycling trucks, and promotional literature. The message on the sticker should be concise, readable, and positive. The logo or symbol on the sticker should be consistent with other program literature.

Special containers should be manufactured from light-weight, soft, blow-molded plastic for ease of handling and durability and should include an attached or embossed promotional message. The container should have rolled or turned edges and rounded corners for safety in handling.

In order to reduce the potential for lifting accidents, special containers should not exceed one foot in depth (i.e., should have capacity for between 25 and 30 lbs of newsprint).

Special containers provided by municipalities should clearly state their ownership. University City, Missouri, prevented loss of newspaper bins by distributing program pamphlets stating "TreeSaver is the property of University City and is assigned to you for use." In Seattle, where no such statement was made on the units or in the program promotion literature, many units were lost.

The present two-sided onion sack does not provide sufficient capacity. By adding a bottom panel, however, the volume of the sack can be greatly increased. The use of a snap clasp, such as that used by the book bag and sleeping bag industries, reduces on-route and processing labor costs. The commonly-used drawstring sack requires more time to unload because string knots must be untied.

Communities collecting unbundled newsprint may wish to use paper shopping bags imprinted with a promotional message to store papers in the home and at the curb.

Communities procuring plastic bins or pans might purchase the mold used to make the containers, to be reused.

2 COLLECTION EQUIPMENT

To collect recyclable materials, source-separation programs may either adapt existing municipal or recycling agency trucks or purchase vehicles that are specially designed for source-separation collection.

ADAPTED EQUIPMENT

Existing vehicles that may be adapted for use in recycling programs include:

- Compactor trucks
- Other municipal or agency trucks, including pickup trucks, stake-body trucks, dump trucks, and scooters.

These vehicles may be used to collect recyclables on residential or commercial routes or to perform auxiliary collection duties, such as collecting newspapers removed from the racks of waste collection trucks and stored on-route at specific locations. Adapted vehicles generally reduce the capital costs of a separate-collection program because they are easily maintained and versatile.

Compactor Trucks

Spare rear, side, or front-loader compactor trucks are commonly used in municipal separate-collection programs.

Compactor trucks used to collect recyclables have capacities ranging between 18 and 29 cubic yards, allowing adequate flexibility to collect the varying material quantities received on a day-to-day basis. Only in two communities did the trucks have to be unloaded more than once a day. Time spent off-route in these communities was minimal, however, as both had storage facilities close to the collection area.

The capacity of refuse compactor trucks is greater than needed for recycling programs. For five programs using compactors for newspaper collection, the average throughput per day was only 60 percent of total vehicle capacity.

Operating costs of compactors used on recycling routes are higher than those of smaller adapted or special vehicles. Newton, Massachusetts, reported an average operating cost of about $2 per ton for their two compactor trucks used for recycling. Purchase costs per ton in cities surveyed ranged from $8,000 to $45,000 (see Exhibit 2). Labor costs of compactor trucks are lower than those of other vehicles because the trucks can be employed on-route for extended periods of time. Furthermore, spare waste collection crew members may be assigned to recycling collection duties. Separate collection of recyclables may, in fact, reduce the number of staff required to operate a community's regular waste collection program. Marblehead, Massachusetts, consolidated refuse collection routes after a substantial quantity of waste had been diverted out of the refuse stream and into the recycling system.

Compactors used in separate-collection programs are able to collect from 0.1 tons to 0.5 tons per labor hour. The volume of materials a program collects depends largely on the frequency with which materials are collected. We found that throughput per labor hour is higher in communities where recyclables are collected by private firms and that a right-hand-drive side-loader is more productive than left-hand drive.

The frequency and cost of maintenance for compactors used to collect recyclables did not appear to exceed those for compactors used for waste collection. For instance, maintenance cost for use of compactors was about $2 per ton in Newton, Massachusetts. Of all the cities surveyed, only Garden City, New York, reported major maintenance problems. The side of the compactor required reinforcement due to bowing created by paper bundles being wedged between the side and the compactor blade.

Program operators were pleased with the use of compactors; as long as the compactors were cleaned before recycling collection assignment, there no were problems of material contamination. Both of the communities using compactors for mixed-material collection reported that the compaction system condensed materials to an acceptable level.

Exhibit 2

Compactor Trucks: Program Data Summary

	Location							
	Downey, CA	**Larchmont, NY**	**Mamaroneck, NY**	**Garden City, NY**	**E. Lyme, CT**	**Boca Raton, FL**	**University City, MO**	**Newton, MA**
Truck type	Side loading	Rear loading	Rear loading	Side loading	Side loading	Rear loading	Rear loading	Rear loading
Size	29 cu. yd.	18 cu. yd.	20 cu. yd.	29 cu. yd.	18 cu. yd.	25 cu. yd.	20 cu. yd.	29 cu. yd.
Capacity	3 tons	N/A	4 tons	8 tons	N/A	8-9 tons	N/A	5.5 tons
Make	Shupak	Leach	Loadmaster	Shupak	Truxmore	Garwood	Heil	Garwood
Residences served	16,000	20,000	5,000	6,200	5,329	12,000	10,000	26,000
Participation rate [a]	20%	90%	25%	80-85%	90%	80-85%	60%	N/A
Materials	Newspaper, cans, and mixed glass	Newspaper	Newspaper	Newspaper	Mixed cans and glass	Newspaper	Newspaper	Newspaper
Location of collection	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside
Recycling collection	Twice/month	Weekly	Weekly	Weekly	Weekly	Weekly	Twice/month	Weekly
Waste collection	Weekly	Twice/week	Twice/week	Twice/week	Weekly	Weekly	Twice/week	Weekly
Same-day collection	Yes	No	No	Yes	Yes	No	No	Yes
Crew size	1 [b]	4 [c]	3 [c]	1 [b]	2 [b]	3 [c]	3 [c]	2 [b]
Hauler	Franchise	Municipal	Municipal	Municipal	Municipal	Municipal	Municipal	Municipal
Fuel/engine	Diesel	Diesel	Gas/8 cyl.	Gas/6 cyl.	Diesel	Gas/8 cyl.	N/A	Diesel
Purchase cost	$8,000 (box only) [d]	$45,000 [e]	$40,000 [e]	$31,000 [d]	$22,000 [d]	N/A	N/A	N/A
Operating cost	N/A	N/A	N/A	$315/month	$75/month	N/A	N/A	$604.2
Maintenance problems	N/A	Axles, clutch	N/A	Added sheet metal to sides; lights; brakes	N/A	N/A	N/A	N/A
Throughput/month	88.4 tons	80 tons	60 tons	67 tons	45 tons	248 tons	50 tons	159 tons

SOURCE: Resource Planning Associates, Inc.

a Average participation rate of residences in the source separation program.

b Separate crew is used for recycling collections.

c Regular refuse crew is used for recycling collections.

d Purchased for source separation program.

e Purchased for refuse collection.

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Other Adapted Vehicles

Smaller, noncompacting vehicles may be adapted for use in recycling programs. Although these vehicles can be operated and maintained at lower costs than compactor trucks, their capacity is less and they lack versatility.

The vehicles with smaller capacities adapted by municipal officials for recycling collection may not be easily adapted to fluctuations in collected volumes and to other functions of recycling and waste collection. Pickup and small stake-body trucks require frequent trips to the storage or processing facility.

Although the large stake-body and box-bed trucks used by the cities of Boca Raton, West Orange, and Deerfield Beach are large enough to accomodate fluctuations in volume, the potential and actual throughput of surveyed adapted vehicles is small (see Exhibit 3). For instance, scooters used in Davis must deposit materials into a larger truck and trailer on route. In addition, the pickup truck used in Temple Terrace must pull a 5-cubic-yard trailer to effectively collect materials.

The wide range of throughput for adaptd vehicles other than compactors has specific implications for cost. In some cases, the labor costs of adapted vehicles exceed those of other recycling collection vehicles, adapted vehicles with small capacities must be unloaded frequently. In addition, many adapted vehicles must be unloaded manually.

On the other hand, the capital costs per ton of throughput are higher for compactors than for other adapted vehicles. With an average capital cost per ton of throughput of $1.70, adapted vehicles are economical, particularly when municipal employees are also available.

Operating costs of other adapted vehicles are less than those of compactors for two reasons:

- Compaction cycling consumes fuel and increases operating costs.
- Compactors have a much lower fuel efficiency, even though the use of diesel engines for waste collection trucks can reduce operational costs.

Exhibit 3

Other Adapted Vehicles: Program Data Summary

	Location									
	Carmel, NY	Carmel, NY	Davis, CA	W. Orange, NJ	Deerfield Beach, FL	Boca Raton, FL	Temple Terrace, FL	Newington, MA	Madison, WI	Racine, WI
Truck type	Pickup	Stake body	Scooters	Box bed	Stake body	Stake body	Pickup	Box bed	Dump truck	Van
Size	48 sq. ft. bed	72 sq. ft. bed	2.5 cu. yd.	14 and 20 ft bed	18 cu. yd.	15 cu. yd.	N/A	6 cu. yd.	12 cu. yd.	12 ft. floor
Capacity	3/4 ton	2 tons	1/2 tons	3 tons glass 6 tons newspaper	4 tons	5.6 tons	1/2 ton	1-1/2 tons	6 tons	3-1/2 tons
Materials collected	Newspaper	Glass, cans	Newspaper	Newspaper, glass	Newspaper	Newspaper	Newspaper	Newspaper	Newspaper	Newspaper
Location of collection	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside	Curbside
Recycling collection frequency	1/month	1/month	1/week	1/week	2/week	1/week	3/week	1/week	1/week	1/week
Waste collection frequency	N/A	N/A	1/week	N/A	2/week	2/week	2/week	1/week	1/week	1/week
Same-day collection	N/A	N/A	Yes	No	Yes	No	No	Yes	Yes	Yes
Residences served	8,000	8,000	8,000	10,800	6,700	12,000	2,300	7,500	42,000	32,000
Participation rate [a]	N/A	N/A	50%	N/A	N/A	80-85%	45%	30-40%	40%	25%
Throughput/month	98 tons	98 tons	100 tons	150 tons	43 tons	248 tons	40 tons	50 tons	200 tons	36 tons
Recycling hauler	Municipal	Municipal	Franchise	Broker	Municipal	Municipal	Municipal	Contractor	Municipal	Municipal
Crew size	3	3	2	3	3	3	3	1	1	2
Fuel	Gas	Gas	Gas	Gas	Gas	Gas	Gas	N/A	N/A	N/A
Capital cost	$4,610 ea. [b]	$3,500 ea. [b]	$3,000 ea. [b]	$10,000 ea. [b]	$900/mo. [b]	$900/mo. [b]	N/A	N/A	N/A	N/A
Operating cost	$75/mo. [c]	$75/mo. [c]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

SOURCE: Resource Planning Associates, Inc.

a. Average participation rate of residences in source separation program.

b. Purchased for source separation program.

c. Combined operating costs for pick-up and stake body trucks.

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However, vehicles with smaller engines and running gear (e.g., clutch, transmission, and axles) must be repaired more frequently, at a higher cost, than heavier-duty compactor vehicles. Small adapted vehicles in several communities required clutch plate replacement, engine rebuilding, and transmission repair.

The use of these available vehicles can create problems. Littering may occur when collecting newspapers with open-bed trucks. One community, Boca Raton, Florida, solved this problem by installing a removable tarp on its stake-body truck. Tarps may also help prevent paper from getting wet in open trucks during rain or snow.

Auxiliary vehicles are used with collection equipment, such as racks, that have very limited capacities. Auxiliary vehicles are either parked on-route to receive excess materials or travel the route to collect materials from predetermined sites. Most auxiliary vehicles are capable of handling the changes in daily received volume without numerous trips to the paper storage or marketing site. The potential throughput for most auxiliary trucks is sufficient to transport recyclable materials for residential recycling programs. In particular, the use of lugger boxes or dump trucks with potential capacities per load of four to six tons of newspaper are adequate for collection program needs. While the capital costs of assigning spare trucks to be parked on-route is high, self-dumping trucks have low labor and operating costs. The lowered use should minimize maintenance problems.

SPECIAL EQUIPMENT

Vehicles or containers that are designed and constructed or procured specifically for program use include racks, trailers, and compartmentalized vehicles.

Racks

The most common form of special equipment used to collect newspaper is the rack. Racks are small metal compartments attached to the side or rear of compactor trucks that are used to collect newspaper during regular mixed-refuse collection rounds.

Side-loading racks provide an effective, inexpensive method of collecting newspaper. However, if significant volumes per truck are received, racks must be unloaded at least once per day, often adding substantial time to collection.

Because the capacity of racks is limited, their contents must be emptied into auxiliary vehicles along the collection route. In spite of the need for auxiliary vehicles, the cost of using racks is low. The labor costs of collecting refuse simultaneously with recyclables by means of a rack are less than those of collecting the two separately. The capital and operating costs for rack use also are low. Racks used in Madison, Wisconsin, were constructed and installed in 8 hours each, at a cost of $175 per rack (see Exhibit 4). The frequency and cost of maintenance for racks are negligible. In addition, program officials using racks did not report littering or problems with wet or contaminated newspaper.

Temple Terrace, Florida, employs a side rack that sits on metal runners. To unload the rack, a crew member pulls the rack out on its runners and tilts it manually until the paper dumps out. This rack has two disadvantages: it is more time-consuming to unload than an open rack and it puts a physical strain on the crew member(s).

Rear or overhead racks are also used in Temple Terrace, Florida. These racks are located above the hoppers of two twenty-five-[illegible] Pakmore rear-loading compactors. Newspapers are thrown onto a flat mesh horizontal platform above the hopper; when the platform is full, the refuse container cable and winch are used to raise the mesh platform to a vertical and, if needed, locked position. When vertical, the platform constitutes the rear panel of the rack. The bottom of the rack is a second hinged panel. Upon return to the municipal equipment yard, the truck is backed up to the newspaper pile. The compactor blade is backed off and the bottom rack panel is unhinged. The newspaper falls past the waste hopper to the ground.

The rear or overhead rack is basically a triangle with dimensions of 7' by 7' by 3'9" (the triangle is formed by the shape of the truck). The rack has a two-cubic-yard capacity and is constructed of a skeletal angle-iron

Exhibit 4

Racks: Program Data Summary

	Location					
	Madison, WI	**Racine, WI**	**Newington, MA**	**Temple Terrace, FL**	**Temple Terrace, FL**	**San Francisco, CA**
Rack type	Side-loading	Side-loading	Side-loading	Side-loading	Rear-loading	Side-loading
Rack size	1 cu. yd.	1 cu. yd.	1.16 cu. yd.	1.2 cu. yd.	2 cu. yd.	3/4 cu. yd.
Rack capacity	600 lbs.	600 lbs.	625 lbs.	700 lbs.	N/A	450 lbs.
Rack dimensions	5-1/4' x 2-1/3' x 2-1/3'	5-1/4' x 2-1/3' x 2-1/3'	5' x 2-1/2' x 2-1/2'	6-1/2' x 2-1/2' x 2	N/A	6' x 2' x 1'
Material collected	Newspaper	Newspaper	Newspaper	Newspaper	N/A	Newspaper
Compactor type	Rear-loading	Rear-loading	Rear-loading	Rear-loading	Rear-loading	Rear-loading
Compactor size	20 yd. yd.	20 or 25 cu. yd.	20 cu. yd	N/A	N/A	N/A
Location of collection	Curbside	Curbside	Curbside	Curbside	Curbside	Backyard
Collection frequency	1/week	1/week	1/week	3/week	N/A	N/A
Residences served	32,000	42,000	7,500	2,266	N/A	N/A
Participation rate*	25%	40%	30-40%	45%	N/A	N/A
Throughput/month	36 tons	200 tons	50 tons	22 tons	N/A	N/A
Hauler	Municipal	Municipal	Municipal	Municipal	N/A	Contractor
Crew size	2	2	3	3	3	3
No. of trucks with racks	21	44	3	1	N/A	N/A
Capital cost	$170	$175	$250	$179	N/A	N/A
Fabricator	Iron Works Co.	Municipality	N/A	Municipality	City	N/A
Expected life	N/A	N/A	N/A	N/A	7 years	N/A

SOURCE: Resource Planning Associates, Inc.

* Average participation rate of residences in the source separation program.

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frame with expanded metal sides and bottom. The large size of the rack, double that of most side racks, eliminates the need to unload on-route.

The Temple Terrace program official did not report any operational costs associated with rear rack use.

Construction of the rack cost approximately $179 for materials, 80 labor hours for design, and an additional 40 labor hours for fabrication and testing. The Temple Terrace overhead rack has a cost of $2.25 per throughput ton, with an estimated life of 7 years. This capital cost is high because an excessive amount of labor is involved in developing and testing the racks.

The use of an overhead rack increases the likelihood of littering and material contamination from moisture. The weight of the materials weakens and tears the wire mesh resulting in gaping holes through which paper will drop. In addition, the mechanism to lock the rack door can fail, creating a safety hazard. The high loading height of the overhead rack creates physical problems for the crew, such as fatigue and lower back pain.

Trailers

Trailers, pulled by refuse collection vehicles, are used to collect one or more recyclable materials, most often newspaper or mixed wastepaper. There are two general types of trailers:

- Single-material
- Multimaterial.

Single-material trailers enable a collection crew to collect significant quantities of wastepaper without unloading paper on-route or returning to the paper storage or processing facility before the route is completed.

In the majority of programs surveyed, potential trailer throughput was significantly greater than actual throughput (see Exhibit 5). Thus, program participation could expand without severely impacting trailer use. If participation is very high, however, as in East Lyme (East Lyme has a per-residence recycling volume of 12 pounds per

Exhibit 5

Single-Material Trailers: Program Data Summary

	Location		
	Enfield, CT	**E. Hartford, CT**	**E. Lyme, CT**
Trailer size	6 cu. yd.	6 cu. yd.	4 cu. yd.
Trailer capacity	3,000 lbs.	3,000 lbs.	2,400 lbs.
Trailer dimensions	9'6" x 5'9" x 3'	9'6" x 5'9" x 3'	8' x 4' x 4'
Axle type	Single	Tandem	Single
Self-dumping	Yes	Yes	No
Trailer used with	Waste collection vehicle	Waste collection vehicle	Recycling collection vehicle
Compactor truck	Rear-loading	Rear-loading	Side-loading
Compactor size	20 cu. yd.	31 cu. yd.	18 cu. yd.
Materials collected	Newspaper	Newspaper	Newspaper
Location of collection	Curbside	Curbside	Curbside
Collection frequency	1/week	1/week	1/week
Residences served	11,000	12,500	5,329
Participation rate *	30%	5-10%	90%
Throughput/month	85 tons	37 tons	32 tons
Recycling hauler	Municipal	Municipal	Municipal
Crew size	3	3	2
No. of trucks with trailers	5	5	1
Capital cost	$3,000 ea.**	$3,220 ea. **	$333 ea.**
Operating cost	$50/month	N/A	N/A
Manufacturer	PacCraft; Reliable Welding	PacCraft	Municipality

SOURCE: Resource Planning Associates, Inc.

* Average participation rate of residences in source separation program.

** Purchased/constructed for source separation program.

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month, as compared to an estimated 8.8 pounds per month per residence in East Hartford and Enfield), the trailer must be unloaded twice each collection day.

The hour and labor hour throughput of single-material trailers exceeds the throughput for racks but does not attain the throughput for compactor trucks.

While the capacity of single-material trailers may be a reason to select them for use in a source-separation collection system, their procurement cost may be a prohibitive factor.

Except in East Hartford, where program participation is low, the costs per ton for trailer procurement and modification are less than those for compactor trucks and slightly more than those for side racks. Per-ton operational costs, available for only one program, are high -- about $3 per ton.

Trailers can range in design, construction, and cost from a heavy-duty trailer, such as the self-dumping trailers purchased for the Enfield and East Hartford programs at a cost of about $3,000 each, to a simple, self-made wood trailer, such as that constructed from a boat frame by East Lyme for $333.

Maintenance problems were reported in all cases, ranging from minor human error problems of run-down batteries to broken axles due to overloading. Taillights were often broken in accidents occurring while the truck and trailer were in reverse.

The three communities using single-material trailers marketed their wastepaper to buyers who accepted wet paper. This may not be the case in other communities. In addition, as with all vehicles carrying open, loose wastepaper, littering can occur due to blowing paper.

In order to collect more than one recyclable material at a time, several communities use trailers with separate bins or compartments.

The potential throughput for multimaterial trailers varies according to the trailer and axle type as well as the capacity of the bins (see Exhibit 6). Trailers used on high-volume routes had to be unloaded at midday before route completion in most programs surveyed. Only in

Exhibit 6

Mutimaterial Trailers: Program Data Summary

	Location				
	Modesto, CA	**Seattle, WA**	**Davis, CA**	**Davis, CA**	**Temple Terrace, FL**
Trailer capacity	5,400 lbs.	2,030 lbs.	1,000 lbs.	11,000 lbs.	2,020 lbs.
Trailer dimensions	12' x 6'	12½' x 6½'	4' x 4' x 3'	26' x 8'	10' x 5'
Bin size	6' x 4' x 4'	46" x 46" x 34"	30 gallons	12' x 8'	2 - 2 cu. yd. 1 - 1 cu. yd.
No. of bins	3	6	4 barrels	1	3
Axle type	Tandem	Tandem	Single	Tandem	Single
Unloading system	Rotating head forklift	Forklift	Manual	Manual & self-dumping	Self-dumping
Trailer used with	Flatbed	Flatbed with bins	Scooters	Pickup	Pickup
Trailer collects	Newspaper, glass	Newspaper, glass, cans	Glass, cans	Newspaper, glass, cans	Glass, cans
Truck collects	Cans	Newspaper, glass, cans	Newspaper	Newspaper	N/A
No. of trailers	2	1	2	1	1
Location of collection	Curbside	Curbside	Curbside	Curbside	Curbside
Residences served	33,500	10,000	8,000	8,000	2,300
Participation rate *	38%	22%	50%	50%	45%
Collection frequency	2/month	1/month	1/week	1/week	1/week
Throughput/month	187 tons	51 tons	146 tons	146 tons	25 tons
Hauler	Agency	Agency	Franchise	Franchise	Municipal
Crew size	2	2	2	2	3
Capital cost of trailer	$3,000 ea. **	$2,900 ea. **	$900 ea. **	$6,500 ea. **	$1,050 ea. **
Capital cost of bins	$95 ea	$240 ea.	N/A	N/A	$30 ea.
Manufacturer	Ecology Action	Hitchman Trailers	Hauler	Hauler	Municipality

SOURCE: Resource Planning Associates, Inc.

* Average participation rate of residences in source separation program.

** Purchased/constructed for source separation program.

Seattle, where the truck had as many bins as the trailer, were program operators able to adjust the collection equipment to accommodate the volume and mix of waste collected.

Capital costs of multimaterial trailers averaged $0.45 per ton over a ten-year vehicle life, compared to the capital cost of other collection equipment. Operational costs for trailers could not be obtained from program officials.

Two programs reported minor maintenance problems similar to those of single-material trailers: broken taillights and brake and axle problems. Minimal downtime was reported. The multimaterial trailers increased handling time because of the need to keep materials separate during unloading. Material marketing problems can also occur as a result of trailers' open tops. In Seattle, a tarp was acquired to minimize moisture problems for paper recovery and to eliminate on-route littering.

Compartmentalized Vehicles

Because they have greater capacities than trailers or trucks with racks, compartmentalized vehicles are used by several communities to collect more than one recyclable. Three types of compartmentalized trucks are commonly employed:

- Rear-loading vehicles
- Compartmentalized dump trucks
- Trucks with bins.

Rear-loading Vehicles

A few communities use open-top packer bodies with separate longitudinal compartments. A rear-loading bin is installed, with matching compartments for separate materials. It is raised above the truck body hydraulically and tilted to dump the materials into the vehicle. At the processing or broker facility, rear doors are opened to unload the materials separately. This vehicle was used in the EPA-sponsored demonstration project in

Marblehead and Somerville, Massachusetts.* With capacities of between 16 and 20 cubic yards, rear-loading vehicles can handle large quantities of materials. Differences in collection rates for various materials can be compensated for by adjustable compartments in the truck and bin.

Capital costs are high for this truck but operating costs do not appear to be excessive, given the age of the vehicles, their capacity, and the amount of fuel consumed in dumping bins on-route. Occasional cross-dumping was described in Newton, where collected glass was contaminated by colored glass accidentally dumped into the clear glass compartment during the bin dumping cycle.

Compartmentalized Dump Trucks

An open-top dump truck with material compartments was used in Lexington, Massachusetts, to collect color-sorted glass and cans. Materials were loaded over the side of the truck into the appropriate compartment. When the truck arrived at the storage or processing facility, the compartments were unloaded into the appropriate containers or storage areas. The Lexington truck had a hydraulically-elevated bed; dividers between the compartments were hinged. To empty each compartment into the appropriate container or pile, kick pins were thrown before each unloading cycle.

The truck had four compartments, with a total capacity of between 12 and 15 cubic yards (see Exhibit 7). Although the partitions were not adjustable, the four compartments varied in size, thus allowing for variations in the amount of various materials collected. Significant changes in the amounts of materials collected, however, necessitated the unloading of compartments before all compartments were full.

Capital costs for the Lexington truck were estimated to be low, and operating and maintenance costs were not excessive. In addition, no material contamination problems were reported.

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* U.S. Environmental Protection Agency. Source Separation in Marblehead and Somerville, Massachusetts: Collection and Marketing (SW-822).

Exhibit 7

Compartmentalized Dump Trucks: Program Data Summary

	Location	
	Newton, MA	**Lexington, MA**
Truck type	Rear loading	Side loading
Size	16 cu. yd.	15 cu. yd.
Capacity	3.2 tons	3 tons
Materials collected	Cans, mixed glass	Cans, glass
Location of collection	Curbside	Curbside
Recycling collection frequency	1/week	1/week
Waste collection frequency	1/week	1/week
Same day collection	Yes	N/A
Residences served	25,500	9,000
Participation rate [a]	5%	25%
Throughput/month	67 tons	29 tons
Hauler	Municipal	Contractor
Crew size	2	1
Fuel	Diesel	Gas
Capital cost	$12,537 ea.[b]	N/A [c]
Operating costs	$3.14/ton	N/A [c]
Maintenance costs	$1,998/yr.	N/A [c]

SOURCE: Resource Planning Associates, Inc.

a. Average participation rate of residences in the source separation program.

b. Purchased for source separation program.

c. These costs were not available but were estimated to be relatively low by program officials.

Trucks with Bins

In order to minimize capital costs while providing sufficient collection capacity for multimaterial routes, several communities employ flat-bed or open-frame trucks with bins or other separate containers. In several of these programs, multimaterial trailers also are attached to the trucks.

The versatility of multimaterial trucks with bins is generally limited. Only the Seattle program, which uses a truck and trailer combination, is able to collect a sizable volume of materials (23.4 cubic yards), while allowing for expected variations in the ratio of daily received materials (see Exhibit 8). The Seattle program uses six bins, carried on both the truck and the trailer.

Programs in Modesto, El Cerrito, and Santa Rosa, California, also use trucks with bins. Truck versatility is low in all three cities. In El Cerrito, program operators chose small trucks with bins due to the hilly, small streets. Although the number of storage containers in the Santa Rosa truck is sufficient to allow for changes in the material mix, the truck's capacity is low. The small number of uniform bins used in El Cerrito limits the versatility of that collection system.

With the exception of Seattle, the multimaterial trucks have limited potential throughput. Frequent trips to the processing or storage facility are required due to the limited truck capacity.

The high productivity in El Cerrito and Santa Rosa is related to significant program participation. Adjusting on a population basis, the four communities have a combined participation rate of 48 percent.

The average capital cost for trucks with bins is about $2.00 per ton. Maintenance problems were reported by several programs. In particular, smaller trucks have brake problems. While the capital cost per ton of trucks with bins may be lower, the frequency and cost of maintenance may be greater than those of other truck systems.

As all multimaterial trucks with bins are manually loaded on-route and as most have relatively low bin heights, cross-dumping does not occur. In Seattle and Santa Rosa, tarps or bin covers were acquired to minimize littering and to protect wastepaper from moisture.

Exhibit 8

Trucks With Bins: Program Data Summary

	Location			
	Modesto, CA	**Seattle, WA**	**El Cerrito, CA**	**Santa Rosa, CA**
Truck capacity	500 lbs.	4,860 lbs.	2,350 lbs.	4,000 lbs.
Container type	Bin, barrels, or cage	Forklift bins	Forklift bins	Forklift bins
Bin size	3.55 cu. yd.	2.1 cu. yd.	1.68 cu. yd.	1.5 and 2 cu. yd.
No. of bins	1	6	3	6
Unloading system	Manual	Forklift	Rotating head forklift	Rotating head forklift
Includes trailer	Yes	Yes	No	No
Truck collects	Cans	Newspaper, cans, glass	Newspaper, cans, glass	Newspaper, cans, glass
Trailer collects	Newspaper, glass	Newspaper, cans, glass	N/A	N/A
Location of collection	Curbside	Curbside	Curbside	Curbside
Residences served	33,500	10,000	9,500	23,000
Participation rate *	38%	22%	50%	76%
Waste collection frequency	1/week	1/week	1/week	1/week
Recycling collection frequency	2/month	1/month	1/week	1/week
Throughput/month	187 tons	51 tons	125 tons	205 tons
Hauler	Agency	Agency	Municipal	Franchise
Crew size	2	2	2	2
No. of trucks	2	1	2	3
Truck capital cost	$6,400 ea. **	$12,000 ea. **	$4,000 ea. **	$6,000 ea.**
Bin capital cost	N/A	$240 ea.	N/A	$350 ea.
Operating cost	$120/mo.	$150/mo.	N/A	N/A

SOURCE: Resource Planning Associates, Inc.

* Average participation rate of residences in source separation program.

** Purchased for source separation program.

DESIGN RECOMMENDATIONS

Source-separation collection vehicles should be safe to use. Loading heights for recycling collection should not be higher than those for waste collection. Swamper steps, stands, and hand-holds should be designed and constructed with safety in mind.

Source-separation collection equipment should be able to be maintained easily and inexpensively. Clutches and brakes on trucks should be designed to absorb the abuse from waste collection activities.

The equipment should be able to collect and transport the range of material quantities received from low-volume days to days with peak participation. If the equipment is used to collect more than one material, the number and type of bins or compartments should be sufficient to handle any changes in the ratio of materials received each day. The capacity of the unit should not be significantly greater than the volume of the highest generation routes, however. In particular, the truck or truck and trailer combination should not be so large as to create driving hazards.

The truck or trailer should be an attractive and visible program symbol. The vehicle should include signs and logos to promote the source-separation collection system.

3 STORAGE EQUIPMENT

In many recycling programs, materials are stored after collection and prior to sale. Materials generally are stored when the costs of transportation to the market in the collection vehicle are prohibitive or the materials buyer restricts delivery to certain minimum quantities. Municipalities and program operators offering recycling drop-off centers also store materials. To store recyclable materials, source-separation programs make use of a variety of mobile and stationary containers (see Exhibit 9).

MOBILE CONTAINERS

Mobile containers are transferable units which are either pulled by or placed on a vehicle. These containers are available in a variety of sizes and can be used to hold different materials for a variety of municipal functions. There are three major types of mobile containers used in source-separation programs:

- Roll-off containers
- Transfer trailers
- Other mobile containers.

Roll-off Containers

Roll-off containers are available in a range of sizes (10-50 yd^3) sufficient to accommodate a variety of materials (see Exhibit 10). The roll-off container can hold various types of materials, allowing for changes in materials and amounts collected.

A thirty-yard container for newspaper can be purchased for $3,000. With an expected life of 15 years and maintenance costs of $35 per year, use of the container costs

Exhibit 9

Storage Equipment: Data Summary

	Roll-off Container	Transfer-Trailer	Other Mobile	Stationary
Volume	10-50 cu. yd.	50-80 cu. yd.	1/8-22 cu. yd.	Any size may be constructed
Capacity	20 cu. yd. - 5-6 tons newspaper, 6-7 tons glass, 2-4 tons metal 30 cu. yd. - 8-9 tons newspaper, 9-10 tons glass, 4-5 tons metal 40 cu. yds. - 11-12 tons newspaper, 12-15 tons glass, 6-8 tons metal	50 cu. yd. - 14-16 tons newspaper 80 cu. yd. - 20-23 tons newspaper	N/A	N/A
Material	Metal	Metal	Metal, wood	Wood, metal, concrete
Cost*	$1,800-$3,500	$7,000-$15,000	Varies	Varies
Resale value	High	High	Possible	None
Availability	Good	Moderate	Varies	N/A
Method of loading	Mechanical/manual	Mechanical/manual	Mechanical/manual	Mechanical/manual
Additional equipment	Roll-off truck	Tractor	Flatbed, tractor, van	Dump truck

SOURCE: Resource Planning Associates, Inc.

* For a 30 yard container: Purchase Cost - $3,000, Maintenance Cost/Life - $525, Estimated Life - 15 years, Throughput/Life - 13,875 tons, Throughput/Cost (over life) - $0.25/ton.

Exhibit 10

Roll-off Containers: Data Summary

Material Stored	Newspaper	Glass	Cans
20 yd^3 container: capacity	5 - 6 tons	6 - 7 tons	2 - 4 tons
30 yd^3 container: capacity	8 - 9 tons	9 - 10 tons	4 - 5 tons
40 yd^3 container: capacity	11 - 12 tons	12 - 15 tons	6 - 8 tons
No. of programs	8	5	5
Common container size	20 - 30	20 - 30	30 - 40
Average monthly throughput	77 tons	44 tons	15 tons
Average no. of monthly shipments	9 - 13	4 - 7	2 - 3

SOURCE: Resource Planning Associates, Inc.

about $0.25 per ton of newspapers it stores.* Several recycling programs lease or rent roll-off containers; monthly costs range between $30 and $40.

Roll-off containers with open tops do not protect materials from moisture or contaminants and therefore cannot be used in programs whose markets have strict moisture specifications. Tarps can be placed on the containers, however, to protect the materials from weather.

Maintenance problems for roll-off containers include:

- Denting by lift-truck forks
- Broken wheels
- Flattened legs due to dropping
- Broken door hinges
- Rusting
- Bent rails due to improper use.

Transfer Trailers

Transfer trailers, ranging in size from 50 to 80 cubic yards (see Exhibit 11), are most appropriate for storing and transporting newspaper. In fact, at those sites from which program data were collected, transfer trailers were used solely to store and transport newspaper. Transfer trailers are often too large to store and transport glass; full loads would exceed weight limits in many states.

Exhibit 11

Capacity of Transfer Trailers

Trailer Size	50 yd^3	80 yd^3
Material stored	Newspaper	Newspaper
Capacity (tons)	14-16	20-23
Average number of monthly shipments	5-6	3-4

SOURCE: Resource Planning Associates, Inc.

* Assumes a purchase cost of $3,000, a 15-year useful life, maintenance at $35/year, and a throughput of 925 tons per year.

All surveyed municipalities using transfer trailers for storage had previously used the equipment in waste collection systems. In most cases, the facility and equipment costs had fully depreciated by the time the equipment was received by the recycling program. Throughput costs are very low for transfer trailers that are used efficiently.

Labor costs for operating transfer trailers are minimal due to ease of operation. Transfer trailers containing compacting equipment have higher capacities and are easier to unload.

Maintenance costs for transfer trailers are not exclusive; common maintenance items include brake and hydraulic system servicing and rust prevention.

The quality of the material output from transfer trailers used by recycling collection programs is high. Large quantities of compacted dry waste newspaper can be delivered at one time to a buyer. The use of closed-top transfer trailers with compactors minimizes moisture and littering problems.

Other Mobile Containers

In addition, other containers such as lugger boxes, 55-gallon drums, and other open-top containers and standard waste collection containers with lids or doors may be used in source-separation programs. Programs collecting smaller amounts of materials or transporting materials frequently to market may use these containers instead of the larger roll-off containers or transfer trailers. The standard containers are the most versatile of the containers because they have the largest capacity. Labor costs for these mobile containers are high because they must be unloaded into a truck or large transport container prior to shipment. The containers, except for the standard containers, will not protect the materials from moisture or contaminants, nor will they keep materials from scattering.

Although maintenance costs for the mobile containers are minimal, they must be used in conjunction with other equipment such as front-end loading compactor trucks, derrick trucks, and lift trucks, which incur higher maintenance costs.

STATIONARY BINS

Stationary bins have been constructed or installed by many municipalities for the storage of materials collected by recycling crews. These bins are usually located at the municipal public works yard, transfer station, landfill, or recycling center. They may be any size and are usually constructed of wood, steel, or concrete.

Throughput limitations are few; some bins contain volumes from a month or two of collection. If constructed from available and excess materials, stationary bins have small capital costs. Proper use of bins minimizes maintenance and repair costs. The need for specific equipment (e.g., front-end loaders) to load and unload bins, however, significantly increases storage and handling costs. Problems occur with material contamination if the materials are stored on gravel or earth.

DESIGN RECOMMENDATIONS

A storage container should be mobile so that it can serve as both a storage and transport bin. As most recycling collection programs do not collect sufficient materials to assign a full-time truck for materials transport and marketing, the storage equipment also should be compatible with the trucking components of the waste hauling or public works system. The storage site should incorporate ramps, platforms, or steps to allow for recycling material drop-off from common forms of trucks (e.g., flatbed, van, tractor). Storage units should be at least twenty cubic yards in size. The storage unit should be self-unloading; additional equipment such as lift trucks or loaders should not be required.

Stationary bins should be constructed or installed on concrete or asphalt to withstand the load and physical abuse of a loader. Such bins should be carefully designed to store a volume of collected material sufficient to be cost-effectively loaded and transported to market. The availability and size of the transport vehicle, the delivery schedule of the buyer, and the expected volume will determine the designed bin capacity.

4 RECEIVING EQUIPMENT

Storage containers typically are moved within a processing facility and onto and off of collection and transportation vehicles by one of the following types of equipment (see Exhibit 12):

- Front-end loader
- Forklift truck
- Pallet truck.

Front-end Loader. The front-end loader, a powered vehicle with a bucket on the front end, is used to scoop up loose materials. Loaders can be used to pick up any material and can adapt to a variety of municipal functions. They are available in many sizes, with a variety of equipment options. Bucket sizes range from less than one-quarter to over three-quarters cubic yards. Smaller loaders (i.e., 25-40 horsepower loaders), which are used by several recycling programs, have lift capacities ranging from 800 to 1,000 pounds. Loaders are generally capable of handling the volume of most recycling collection programs.

The cost of a front-end loader significantly affects the economics of a recycling program. Over a 10-year life, the typical $48,000 capital cost of a 3-cubic-yard loader is equivalent to about $1.80 per ton handled. Many communities offset these costs by using their front-end loaders for other public works duties. For example, Newton, Massachusetts, uses its front-end loader for recycling only about 15 percent of the time; the recycling program, accordingly, only pays 15 percent of its cost.

Forklift Truck. Forklift trucks are commonly used by collection programs that process materials or use bins for collection. They move containers or paper bales, most commonly by slipping a fork under the container or bale, lifting it slightly, and transporting it to the desired location. Other forklift models have grippers that fit

Exhibit 12

Receiving Equipment: Data Summary

	Front-end Loader	Forklift Truck	Pallet Truck
Height		10' - 12' with extended forks	2' - 3'
Length		7' - 9'	30" - 70"
Width		3' - 4'	20" - 34"
Volume	1/4 - 3/4 cu. yd.		
Capacity		Up to 5 tons or higher with extended forks	Up to 3 tons
Material			Welded steel with metal or polyurethane wheels
Cost	$45,000 - $50,000	$3,000 - $15,000	$425 - $750
Purchase cost	$48,750	$5,000	$425
Operation/maintenance cost/life		$6,720	(Minimal)
Estimated life	10 years	10 years	10 years
Throughput/life	27,120 tons	12,000 tons	3,000 tons
Throughput/cost (over life)		$1.00/ton	$0.15/ton
Percent of time used for recycling	13%	100%	100%

SOURCE: Resource Planning Associates, Inc.

around barrels or drums, rotating forks that turn containers over for dumping, or side-shifting heads that move containers sideways.

Forklift trucks are available in a variety of sizes, with varying lifting capacities and equipment options. For instance, forklift truck engines and motors are available in gas, propane, and electric models.

The throughput of fully-utilized lift trucks in the program surveyed ranged from 250 to 625 tons per month. As no surveyed program collected more than 250 tons per month of recycled materials, the capacity of the forklift trucks was sufficient.

Forklift trucks cost up to $15,000; operating costs range from about $0.25 to $0.85 per ton of materials lifted. Accordingly, total costs of a forklift truck over a 10-year life average about $1.00 per ton handled. Several programs reported excessive maintenance costs for forklifts. In one case, maintenance costs were double other operational costs.

Pallet Truck. Pallet trucks provide an inexpensive method of conveying bins between processing and storage locations within a processing facility. The trucks have forks that slip under containers or bales, placing them on a pallet about two inches off the floor. The truck jacks up materials placed on the pallet and moves the pallet laterally on wheels. Pallet trucks are available with equipment options such as skid adapters and backstops. They work best on a smooth and level concrete floor and, depending on the particular model, can lift up to three tons. Pallet trucks are safe to use; they are operated manually and operators require no training.

Design Recommendations

According to the recycling system design, the best available conveyance technologies are:

- For collection bin unloading: rotating head fork-lift truck
- For transport from collection to processing equipment: belt conveyors

- For conveyance from processing to storage: pneumatic conveyors (metals only)
- For transport from temporary storage to transport equipment: front-end loaders.

5 CONVEYANCE EQUIPMENT

Conveyor belts and pneumatic tubes are commonly used to transport loose recyclable materials within a processing facility (see Exhibit 13).

EQUIPMENT DESCRIPTIONS

Conveyor Belts. Conveyor belts made of rubber, PVC, or steel are used by several successful collection programs to move material from bins to processing equipment or from processing equipment to storage containers. For instance, magnetically-separated ferrous cans are conveyed on a belt from a magnetic separator to a can flattener in Seattle, Washington. In Grand Rapids, Michigan, collected glass bottles and jars are manually sorted and processed from a variable-speed conveyor.

While the data are limited, maintenance costs and downtime for conveyors seem excessive. For instance, one program official reported severe belt abuse from the collection of glass shards from the crusher at the bottom pulley housing. Another operator reported high downtime on the metals processing line due to conveyor maintenance needs. Frequent needs for belt repair and replacement by recycling programs were also reported. For a can conveyor with a 15-year life, a purchase price (including installation) of $300, and an average monthly throughput of 16 tons, throughput cost over the life of the conveyor is $0.10/ton. A glass conveyor with a 10-year life, $1,000 purchase price (also including installation), and an average monthly throughput of 38 tons, would have a throughput cost per ton of about $0.20.

Pneumatic Tubes. In several source-separation collection and processing systems, materials are conveyed by air. Pneumatic tubes are most often used to convey metals, even though they also can be used to move shredded paper.

Exhibit 13

Conveyance Equipment: Data Summary

	Conveyor Belts		Pneumatic Tubes
Height	3' - 5'		3' - 7'
Length	Varies		7' - 20'
Width	1' - 5'		2' - 3'
Weight	N/A		1,200 - 1,800 lbs.
Volume	Varies		Varies
Cost	$100 - $2,000		$500 - $2,000
Power requirements	110 - 200 volts		4 - 6 horsepower motor, 220 - 240 volts, 3 phase
	Can Conveyor	**Glass Conveyor**	
Purchase cost (including installation)	$300	$1,000	$1,000
Operating/maintenance cost	N/A	N/A	N/A
Estimated life	15 years	10 years	15 years
Throughput/life	2,880 tons	4,560 tons	2,880 tons
Throughput/cost (over life)	$0.10/ton	$0.22/ton	$0.35/ton

SOURCE: Resource Planning Associates, Inc.

Pneumatic tubes are available separate or joined to processing equipment. Separate units, including a feed hopper, blower tubing, and wiring, cost between $1,000 and $1,400.

As shredded aluminum and flattened tin cans are lightweight, they can be transported in bulk by a pneumatic tube. In comparison to some processing and conveying equipment, pneumatic tubes are relatively inexpensive to use. An average pneumatic tube has a life of 15 years and costs $0.35 per ton of materials it conveys.

The programs surveyed using pneumatic tubes reported maintenance problems including clogging of metals in the tubes and excessive noise when metals are conveyed.

Design Recommendations

Recycling programs using belt conveyors should consider four design modifications or procurement recommendations:

- Use of hanging mobile switch cords for conveying functions that require processing labor (e.g., glass sorting or can-flow monitoring)
- Modification to variable-speed belt conveyors
- Acquisition of belt material and repair kits to lower downtime for belt refurbishing
- Use of mesh pulleys for glass conveyors tied to crushers to minimize belt tear due to glass shards.

The excessive noise from the operation of pneumatic tin can conveyors, reported at 102 decibels at the end of the tube and 70 decibels at twenty feet, is a problem. Manufacturers are currently developing deadening systems. Equipment in use should be retrofitted to lower the noise from can conveying by air.

6 PROCESSING EQUIPMENT

Many recycling collection systems in the United States, particularly those that are privately operated, process collected materials. Recycling collection program officials choose to process materials for two reasons:

To reduce volume. In order to store and transport materials economically, several recycling programs shred, flatten, or crush collected materials. In particular, metal cans and corrugated paper are processed for volume reduction. The preparation of recyclables to attain the gross shipping limits of transport vehicles becomes more important as fuel costs increase.

To increase material value and marketability. The primary purpose of processing is to alter a material to meet the buyer's needs. Several source-separation collection systems process materials to segregate marketable components. For instance, one program in California collects mixed cans and then uses a magnetic separator to sort them into ferrous and aluminum components. This system was selected to increase participation by reducing the effort required of householders and to reduce or eliminate on-route scavenging of the high-income aluminum volume. Other recycling programs process materials to meet market requirements, such as contaminant specifications or market grades. A secondary benefit of processing can be an increase in the number of potential buyers. For instance, loose aluminum cans may be purchased by only one or two local buyers while shredded or flattened and baled cans can be marketed nationwide.

GLASS CRUSHER

Several recycling collection programs crush bottles and jars before shipping them to cullet users (see Exhibit 14). In addition, intermediate handlers who purchase secondary materials from curbside collection

programs use crushers to process glass containers before selling them to an end-user. Crushers have two purposes:

- To increase density. Manufacturers claim that certain crushers produce a 10-to-1, or greater, size reduction.
- To enable contaminant removal. By removing ferrous closures magnetically and by screening nonferrous caps, some crushers clear cullet of unwanted materials.

Glass crushers are able to handle about 0.3 to 2.5 tons per hour of glass, which is the volume of most separate-collection systems (i.e., 30-100 tons per month).

Glass crushers are available in a range of sizes and power outputs (see Exhibit 15). The larger and more powerful crushers are needed to crush glass into small particle sizes (less than 1/2 inch).

Exhibit 14

Glass Crushers: Program Data Summary

Program	Seattle, WA	Grand Rapids, MN	Recycling Enterprises, CT
Throughput/month	20 tons	65 tons	3,000 tons
Level of use	35%	15%	100%
Staff required	2	5	3 - 5
Maximum processable size	Glass jar	–	Glass jar
Potential throughput	2 tons/hour	–	25 tons/hour
Size of output	1" minus	2" minus	1/2" minus
Method of infeed	Conveyor	Conveyor	Conveyor
Method of outfeed	Conveyor	Gravity drop	Gravity drop
Crushing mechanism	Multiple hammers	Rotating chains	Multiple hammers
Problems	Conveyor wear; dust	Dust	Dust

SOURCE: Resource Planning Associates, Inc.

Exhibit 15

Glass Crushers: Manufacturer Data Summary

Size	1/2 Horsepower	5 - 15 Horsepower	25 Horsepower
Purchase cost	$300 - $600	$1,200 - $3,000	$21,000
Size of output	3" minus	1" minus	1/2" minus
Power requirements	110 volts	220 - 440 volts	220 - 440 volts

SOURCE: Resource Planning Associates, Inc.

Major maintenance problems with equipment used in conjunction with crushers were reported by the surveyed programs. For instance, one program experienced excessive in-feed conveyor belt wear due to the abrasiveness of the glass. Hammers, bearings, and other moving parts wear quickly due to the abrasiveness of glass and glass dust. Therefore, these component parts must be replaced regularly.

PAPER BALERS

The most traditional paper processing unit is the paper baler. Many programs use balers to package wastepaper in a marketable and transportable form. Balers can reduce the volume of whole paper 3:1 and shredded paper blown into the baler 10 to 15:1.

Balers are available in a variety of sizes and types. The downstroke baler is the most common (see Exhibit 16); it is mainly used by recycling collection programs that also reclaim corrugated and office paper. Upstroke, or pit balers, and horizontal balers are used by larger programs, including those with corrugated paper recovery systems. Balers may be hydraulically driven or electrically powered.

Most paper balers are versatile. Other than large-sheet corrugated cartons, balers as small as a 48"-chamber downstroke unit can accept and adequately compress various grades of wastepaper. No equipment downtime or alteration is required to bale different paper grades.

Exhibit 16

Characteristics of Paper Balers
Manufacturer Data Summary

Baler	1	2	3	4	5	6	7	8	9	10
Type	Downstroke	Downstroke	Downstroke	Downstroke	Downstroke	Downstroke	Upstroke	Horizontal	Horizontal	Horizontal
Bale size	48"	48"	60"	60"	60"	60"	60"	60"	72"	72"
Bale weight (lb)	500-600	400-600	600-700	600-1,000	600-800	600-800	700-800	1,000-1,500	1,000-1,500	1,000-1,500
Horsepower	5.0	7.5	7.5	7.5/10	10	5	10	25	10/20	40
psi	24	N/A	28	N/A	N/A	N/A	28	54	45-55	54
Size of cylinder	5"	N/A	6"	N/A	5"	6"	N/A	7"	6"	7"
Shipping weight (lb.)	3,250	3,800	4,500	5,060	4,000	6,000	12,000	N/A	6,000	N/A

Program Data Summary

Program	Santa Rosa, CA	Carmel, NY	Modesto, CA	Boulder, CO
Type	Pit (upstroke)	Downstroke	Downstroke	Pit (upstroke)
Horsepower	N/A	7.5	10	7.5
Drive	Hydraulic	Chain/mechanical	Hydraulic	Chain/mechanical
Level of use	100%	50%	75%	100%
Throughput	732 tons/month	85 tons/month	60 tons/month	35 tons/month
Cost	$40,000 *	$200 rent/month *	$5,900 *	$5,500 *

SOURCE: Resource Planning Associates, Inc.

* Purchased/rented for source separation program

The program data indicate that the potential throughput of a paper baler is limited by its chamber loading system. Manual baler loading severely restricts throughput; the range of throughput for manually-loaded balers ranges from one-third to one ton per labor hour. On the other hand, a pit baler loaded by a front-end scoop can bale over four tons of wastepaper per man-hour. Some balers automatically eject bales while others require manual bale removal. Balers have a longer life-cycle than other processing equipment since wastepaper is the least abrasive and most flexible of recyclable materials. The capital cost per ton for paper balers is low; it ranges from $0.45 to $1.30 per ton, over a 10-year life. Bale ties or strapping costs range from $0.90 to $2.00 per ton of paper processed. Program operators reported only minor maintenance problems with balers; problems most frequently were associated with hydraulic fitting or chain link damage.

METAL PROCESSING EQUIPMENT

Equipment to process source-separated residential metal cans is employed for various purposes:

- To separate ferrous and nonferrous components of cans
- To flatten cans in order to reduce shipping costs or to conform to buyer specifications
- To shred cans in order to reduce shipping costs and release moisture trapped in cans.

Magnetic Separators

Two types of magnetic devices are commonly used to separate metallic components of cans:

- A magnetic head pulley with an incline conveyor, which ejects nonferrous materials before pulling ferrous materials around the head pulley to fall in a separate flow

- An electromagnet with or without a belt, which pulls ferrous metals to it from a conveyor below carrying mixed metals.

The magnetic head pulley units, used to separate cans received on-route (see Exhibit 17), are capable of processing the volume from most source-separation collection systems and can accommodate changes in material flow (e.g., if local beverage canners shift packaging forms). The units' versatility and throughput, however, do not reach the levels indicated by manufacturers. This discrepancy is due in part to the fact that separator manufacturers have traditionally served the aluminum recycling industry; the manufacturers' estimated throughput applies to the processing of an only slightly contaminated aluminum flow. The shift to a predominantly ferrous waste stream retards throughput.

The labor requirements of separators vary according to the quality of the can volume (e.g., the degree to which it is contaminated with other metal items or bottles). Labor requirements for processing aluminum are high because the material specifications for recycled aluminum are strict; minimal contamination is allowed. Material loading, flow monitoring, and bin moving are the most labor-intensive aspects of a separation system. The actual operation of the separator requires little effort.

Over an estimated 10-year life, surveyed separators have a minimal capital cost (i.e., from $0.75 to $3.40 per ton). It should be noted that all collection programs using separators also provide buy-back systems for aluminum beverage containers.

Program officials reported few maintenance problems with separators. One program experienced belt wear due to misaligned pulleys. Bearing lubrication was needed on a monthly basis at a second site.

Only one program official noted potential contaminant problems with separator use. By increasing the belt angle, thereby lowering the throughput per hour, the problem was eliminated. Operators did not report complaints of contamination from materials buyers. Increased use of bimetal cans in some market areas, however, may diminish the ability of operators using separators to meet the requirement of ferrous can buyers who will not accept a ferrous/bimetal mix.

Exhibit 17

Characteristics of Magnetic Separators

Manufacturer Data Summary

	1	2
Type	Head pulley	Head pulley
Belt type	Rubber/nylon ply	PVC
Motor size	1/2 horsepower	1.2 horsepower
Wiring	110/220 volts	220/440 volts
Weight	760 lb.	650 lb.
Belt hinges	Minet	Alligator
Throughput	1.25 tons/hour	4 tons/hour
Effectiveness *	N/A	99% at 45°

Program Data Summary

Program	Seattle, WA	El Cerrito, CA	Modesto, CA	Recycling Enterprises
Type	Pulley	Pulley	Pulley	Electromagnetic
Level of use	20%	30%	50%	100%
Maximum size can	1 gallon	1 gallon	1 gallon	No. 10 can
Capital cost	$1,995	$2,500	$1,885	N/A
Hopper size	1.1 yd^3	3 yd.	N/A	N/A
Belt type	Nylon/PVC	N/A	Rubber	N/A
Horsepower	1/2	3/4	N/A	N/A
Voltage	220	220	440	480
Throughput	2 tons/day	N/A	6 tons/day	1/2 ton/day
Effectiveness: *				
ferrous in alum	5%	1%	1-2%	N/A
alum in ferrous	2%	less than 1%	1-2%	N/A

SOURCE: Resource Planning Associates, Inc.

* Contamination of materials caused by equipment.

Can Flatteners

Flatteners are used to reduce the volume of cans to attain shipping weight limits and to meet the specifications of some buyers of scrap cans. A number of detinners and copper precipitation processors pay a premium for flattened ferrous cans. Alcoa's purchase specifications for scrap aluminum cans also stress flattening.

Can flatteners can adequately process both ferrous and aluminum cans, reducing volume by up to 400 percent (see Exhibit 18). Flatteners have capacities of two to four tons per day, thus meeting the needs of most source separation programs. The throughput of flatteners used in surveyed programs was lower than that reported by manufacturers, however (see Exhibit 18), probably because of factors such as material loading, number of sorters/monitors, and speed and angle of magnetic separator belts. Flatteners require routine maintenance, such as belt repair and bearing lubrication.

Can Shredders

Several recycling collection programs have procured shredders to reduce aluminum cans to popcorn-size nuggets. In this manner, scrap aluminum can be effectively marketed and shipped.

The present generation of shredders is constructed so that the shredder screen can be replaced easily to vary the density of the aluminum product to meet the requirements of different buyers. Aluminum smelters and end-users have different density requirements for purchased scrap. For instance, Alcoa desires a 14-pound-per-cubic-foot shred while Kaiser purchases aluminum at 20 to 25 pounds per cubic foot. The use of shredder plates with larger holes decreases the output density while increasing productivity. In addition, special plates with 2" x 4" slots can be inserted into a shredder to enable it to process ferrous cans.

The potential throughput of shredders, ranging from one-quarter to two tons per hour, greatly exceeds the processing needs of most recycling collection systems. The information from surveyed sites (see Exhibit 19) confirms that shredder throughput is more than sufficient for most programs.

Exhibit 18

Characteristics of Can Flatteners

Manufacturer Data Summary

	1	2	3
Conveyor-infeed	1' x 12'	1' x 7'	1' x 4'
Conveyor motor	1/2 horsepower	1/2 horsepower	1/2 horsepower
Flattener motor	5 horsepower	5 horsepower	7.5 horsepower
Wiring	220 volt	230 volt	220/440 volt
Reduction: rated	4 : 1	N/A	4 : 1
Weight	1,400 lb	N/A	2,000 lb
Cost	N/A	$6,950	$4,700

Program Data Summary

	Seattle, WA	Grand Rapids, MI
Type	Counterrotating wheels	Counterrotating wheels
Wheel type	One rubber, one steel	Both rubber, filled with sand
Level of use	30%	12%
Reduction: actual	2 : 1	2 : 1
Cost	$4,820 *	N/A
Throughput	3.8 tons/month	9.5 tons/month

SOURCE: Resource Planning Associates, Inc.

* Purchased for source separation program.

Exhibit 19

Characteristics of Can Shredders

Manufacturer Data Summary

	1	2	3
Product density	14 - 25 lb/ft^3	10 - 30 lb/ft^3	N/A
Maintenance cost	$4 per ton	$1.20 per ton	N/A
Size/throughput	25 hp; 500 lb/hr	N/A	30 hp; 500 lb/hr
	50 hp; 1,000 lb/hr	50 hp; 1,000 lb/hr	100 hp; 2,000 lb/hr
	150 hp; 4,000 lb/hr	75 hp; 2,000 lb/hr	N/A
	N/A	100 hp; 3,000 lb/hr	N/A
	N/A	125 hp; 4,000 lb/hr	N/A
Cost	500 lb/hr = $8,500	N/A	500 lb - $8,500
	1,000 lb - $10,250	1,000 lb = $13,750	2,000 lb = $17,550
	4,000 lb = $18,200	2,000 lb = $14,800	N/A
	N/A	3,000 lb = $15,000	N/A
	N/A	4,000 lb = $15,400	N/A

Program Data Summary

	El Cerrito, CA	Modesto, CA
Product shredded	Aluminum	Aluminum
Horsepower	50	30
Electrical	220 volts	440 volts
Level of use	100%	75%
Hopper size	3 yd^3	2.5 yd^3
Crew size	1	1
Rated throughput	1,000 lb/hr	1,000 lb/hr
Actual throughput	500 lb/hr*	700 lb/hr
Cost	$13,000 **	$2,300 **

SOURCE: Resource Planning Associates, Inc.

* Breakers pop due to low amperage at site, creating excessive downtime.

** Purchased for source separation program.

With an estimated 10-year life, the per-ton capital cost of the shredder is minimal in comparison with the total value of the material (from $0.30 to $2.60 per ton). While the actual productivity of the shredders surveyed was less than the manufacturer's rating (see Exhibit 19), one shredder was six years old and the second had electrical problems. Labor requirements of shredders are slight: if the material flow is relatively contaminant-free, the shredder operator is relegated primarily to feeding in and storing materials.

Shredders require extensive maintenance and upkeep. The manganese steel hammers and plates may need to be hard-surfaced, particularly if the material flow is contaminated. Bushings and bearings may require replacement. Most shredder manufacturers provide on-site assistance during shakedown to train users in shredder upkeep and repair. With proper maintenance, however, shredders deliver a dense metallic nugget that meets buyers' specifications.

SCALES

Program operators weigh recyclable materials to gauge the impact of their source-separation collection programs and to check buyer weight reports. To weigh their materials, operators use one of two kinds of scales:

- Small platform scales, used to weigh bins of collected or processed material
- Large in-place truck scales, which are generally shared with other municipal agencies and are often located at waste transfer stations or landfills.

Scales are manufactured in various sizes and types, and have varying methods of displaying weight data. For instance, a one-half-ton platform scale can indicate weight by:

- A calibrated balancing beam with small weights
- A full stand-up dial
- An electronic read-out.

The average cost of a beam scale is one-seventh that of an electronic scale of the same size. Available scales are adequate to meet the needs of collection programs; they may be acquired with a minimum calibration of ten pounds and a maximum calibration of fifty tons (see Exhibit 20).

The experience of recycling program operators suggests that scale use is minimal. In addition, labor costs are insignificant, except in the case of beam scales, where a scale operator must manually calculate the bin or truck weight. While difficult to gauge, the estimated per-ton cost for scale use is minimal, particularly given the low use and extended life of most scales. Over a 10-year life, capital costs for scales used exclusively by recycling collection programs range from $0.20 to $0.50 per ton of material weighed.

With the exception of maintenance problems, scales worked effectively for the collection programs surveyed. Unfortunately, however, recycling collection operators reported severe maintenance costs with scale use. In particular, small platform scales used to weigh collection and processing bins were easily damaged by improper bin placement. Damaged weighing mechanisms and dial faces also were reported.

DESIGN RECOMMENDATIONS

Program officials should select processing equipment that is adequate to process the volume of materials received by their programs and sufficiently flexible to accommodate fluctuations in participation and volume. To achieve the greatest effectiveness, the components of a processing system should be compatible and fully integrated.

Officials should pay close attention to safety when selecting processing equipment because its many functions (e.g., tearing, compressing, flattening, crushing, and shredding) lend themselves to accidents. In addition, they should select equipment requiring the least amount of labor for operation.

Exhibit 20

Scales: Program Data Summary

Program	Seattle, WA	El Cerrito, CA	Modesto 1, CA	Modesto 2, CA	Wellesley, MA	Recycling Enterprises, CT
Type	Platform	Platform	Platform	Truck	Truck	Truck
Size	3' x 4'	3' x 4'	5' x 5'	9' x 25'	10' x 24'	10' x 45'
Maximum weight	3/4 ton	1/2 ton	3 tons	5 tons	50 tons	50 tons
Level of use	3%	50%	25%	10%	N/A	12%
Capital cost	$1,790 *	$80/month *	$4,300 *	N/A	$7,000	N/A

SOURCE: Resource Planning Associates, Inc.

* Purchased for source separation program.

Glass crushers should be totally enclosed to minimize safety, particle, and dust problems. Materials should be conveyed into the crusher, and the cullet conveyed or dropped out of the unit.

Balers should receive paper by belt conveyance and eject paper with a manual or power winch.

Magnetic separators should be fed by a conveyor that can be adjusted to allow for differences in received volume and composition. Mobile on-off switches can increase the efficiency of the operation and avert certain safety problems.

Can flatteners and shredders should contain mechanisms to feed in materials automatically and to convey or drop flattened materials into a storage compartment. Flatteners and shredders should be enclosed in a sound-deadened compartment to reduce noise levels. Mobile operation switches are a valuable addition to these units.

Scales should be easy to operate and should calculate weight data automatically.

Appendix A

SUMMARY OF RESEARCH METHODOLOGY AND ASSUMPTIONS

RPA was commissioned by EPA to develop a user's manual for source-separation collection and processing equipment that would be useful to EPA, municipalities, and equipment manufacturers. RPA was also asked to develop a final report analyzing the effectiveness of various pieces of equipment. This section of the final report summarizes the project methodology and research assumptions.

The initial research activity involved several identification tasks. First, in cooperation with EPA, we identified the audience of the user's manual. Once the primary audience -- municipal sanitation and public works officials -- had been defined and their specific needs analyzed, the appropriate type of information was identified.

Secondly, we devoted significant effort to identifying equipment to be examined. We decided to focus on proven and available equipment and to collect data from equipment manufacturers as well as equipment users.

The first step in equipment identification and selection involved consultation with staff of the Office of Solid Waste of the U.S. Environmental Protection Agency. U.S. EPA personnel, through their Resource Recovery Technology Seminars, have visited source-separation collection programs throughout the United States. In addition, equipment information was available from recent EPA source-separation program grants (Somerville and Marblehead, Massachusetts; Nez Perce County, Idaho; Duluth, Minnesota; San Luis Obispo, California). Lastly, an EPA document (David Cohen, A National Survey of Separate Collection Programs (SW-778) 1979) contained a useful set of recycling program information sheets. From these sources, an initial list of recycling collection programs was compiled and broad types of equipment employed in each program were identified.

Although they were useful in formulating an initial list, EPA data needed to be supplemented. The EPA data sheets needed updating, little information was available from the EPA on the use of processing equipment, and the EPA lacked information from equipment manufacturers. In order to refine and expand the list of recycling collection programs and equipment for research consideration, the project staff undertook four additional activities, including:

Literature search. The solid waste management and public works trade press were reviewed for program and manufacturer information. Materials available from government libraries were studied. The literature and files of various solid waste management associations also were surveyed for additional equipment information.

Telephone interviews. Research project staff contacted representatives of the following organizations to seek information:

- National Solid Waste Management Association (NSWMA)
- NSWMA's Waste Equipment Manufacturers Institute (WEMI)
- National Center for Resource Recovery (NCRR)
- American Public Works Association (APWA).

Letters to associations and publications. In order to seek the widest input, a letter (see Exhibit 21) was sent to the organizations listed in Exhibit 22 requesting each group to inform its members of the need for program and equipment information. In addition, a press release (see Exhibit 23) was provided to the following solid waste publications:

- Solid Waste Report, April 23, 1979
- Solid Wastes Management, May 1979
- Recovery Engineering News, April 1979
- National Waste News, May 1979.

Copies of articles printed in these publications are provided in Exhibit 24.

Exhibit 21

LETTER TO ASSOCIATIONS AND SOLID WASTE PUBLICATIONS

Resource Planning Associates, Inc. is conducting a study for the Environmental Protection Agency on the effectiveness of collection, storage, conveyance, and processing equipment used by cities in their separate-collection recycling programs. We are interviewing city officials across the country whose separate-collection programs appear to be operating successfully. We are interested in their management techniques and any innovative equipment they may be using. From our study, we hope to assemble a manual that can be used by local governments as a guide to separate-collection program techniques and equipment.

We hope that you will assist us by announcing our study to your members. We are especially interested in informing local government officials and private materials processors about the study and the manual, which will be ready for distribution in late 1979. An announcement in your publication, which reaches many of these individuals, would be most helpful and greatly appreciated.

We have enclosed a sample article about the equipment study that you may wish to use in your publication. Please contact Lawrence Oliva at (202) 452-9770 if you have any questions. Thank you for your cooperation. We look forward to hearing from you.

Sincerely,

Henri-Claude Bailly
Principal

Exhibit 22

SOLID WASTE ASSOCIATIONS AND PUBLICATIONS CONTACTED

Aluminum Recycling Association
American Institute of Planners
American Public Health Association
American Public Works Association
APWA Reporter
Association of Metropolitan Sewarage Agencies
Conservation Foundation
Environment Magazine
Environmental Action Foundation
Environmental Action, Inc.
Environmental Defense Fund
Environmental Law Institute
Environmental Policy Center
EPA Journal
Governmental Refuse Collection & Disposal Association
Institute for Local Self Reliance
Institute of Scrap Iron and Steel
Institute for Solid Waste, American Public Works Association
Izaak Walton League of America, Inc.
League of Women Voters Education Fund
National Association of Counties
National Association of Recycling Industries
National Audubon Society
National Center for Resource Recovery
National Conference of State Legislatures
National Governors' Association
National League of Cities
National Municipal League
National Solid Waste Management Association
National Waste News
National Wildlife Federation
Natural Resource Defense Council
Phoenix Quarterly
Recovery and Energy Review
Recovery Engineering News
Resource Recovery Report
Sierra Club
Solid Waste Report, Business Publishers, Inc.
Solid Wastes Management, Communication Channels, Inc.
Technical Information Project
Urban Environmental Conference
Urban Land Institute
Waste Age, Three Sons Publishing Company
Wilderness Society

Exhibit 23

Sample Press Release: EPA Source-Separation Equipment Study

Resource Planning Associates, Inc. (RPA) is conducting a study for the Environmental Protection Agency (EPA) on the effectiveness of collection, storage, conveyance, and processing equipment used by cities in their separate-collection recycling programs. RPA is interviewing city officials across the country whose separate collection programs appear to be operating successfully from a management and equipment standpoint. From the study, RPA plans to assemble a manual that can be used by local governments as a guide to separate-collection program techniques and equipment. Both the study and manual will be completed and ready for distribution in late 1979.

RPA is interested in learning about other separate collection programs that are well-managed and that are using innovative equipment so that the study can be as comprehensive as possible. If you know of any cities operating separate collection programs, please contact Lawrence Oliva at:

Resource Planning Associates, Inc.
1901 L Street, N.W.
Washington, D.C. 20036
(202) 452-9770

Press Releases

Exhibit 24

Wastes Line

City separate-collection recycling equipment to be studied for EPA

Resource Planning Associates, Inc. (RPA), is conducting a study for the Environmental Protection Agency on the effectiveness of collection, storage, conveyance, and processing equipment used by municipalities and private refuse haulers in separate-collection recycling programs. RPA is interviewing city officials and private haulers across the United States whose separate-collection programs appear to be operating successfully from a management and equipment standpoint. From the study, RPA plans to assemble a manual that can be used by local governments and private materials processors as a guide to separate-collection program techniques and equipment. Both the study and the manual will be completed and ready for distribution late this year, according to the firm.

RPA is interested in learning about other separate collection programs so that the study can be as comprehensive as possible. Cities and private refuse haulers operating separate collection programs should contact Lawrence Oliva, Resource Planning Associates, Inc., 1901 L St., N.W., Washington DC 20036. Phone: 202/452-9770.

Solid Wastes Management, May, 1979, page 16.

Solid Waste Report, April 23, 1979, page 71.

Resource Planning Associates, Inc., Washington, D.C., wants to talk with officials representing cities with successful separate collection/recycling programs. Firm is conducting a study for the U.S. Environmental Protection Agency on the effectiveness of collection, storage, conveyance and processing equipment used in municipal separate collection/recycling programs. On the basis of the study, RPA will prepare a manual for use by local governments as a guide to separate collection program techniques and equipment. Individuals wishing to provide input or who otherwise have questions about the project should contact Lawrence Oliva, Resource Planning Associates, Inc., 1901 L St., N.W., Washington, D.C. 20036, (202) 452-9770.

* * *

Conferences. Project staff attended three expositions and conferences at which program and equipment information were available. These included:

- National Solid Waste Management Association, 1979 International Waste Equipment and Technology Exposition, Kansas City, Missouri, May 2-4, 1979.
- California Resource Recovery Association, 1979 Annual Conference, Santa Barbara, California, May 6-8, 1979.
- Appropriate Community Technology (ACT) Fair, Washington, D.C., April 30-31, 1979.

Then we selected criteria for evaluating programs and equipment to be examined further. After discussion with the EPA Project Officer, four categories of evaluation criteria were designated, consisting of:

- Performance: capability to handle different types of materials, versatility, and quality of output
- Capacity: the amount a piece of equipment can process and its ability to accommodate the system needs
- Efficiency: the yield of a piece of equipment versus the total cost in hardware and labor
- Reliability: the performance history of a piece of equipment.

Having selected evaluation criteria, we identified programs that were successfully using equipment, and recycled at least 50 tons per month of materials. We also considered the program's geographical location and its years in existence.

The programs considered to have the most effective collection systems were selected for visits. We took care to select a representative sample of programs from five separation system scenarios:

- Multimaterial separate collection (collection of more than one recyclable material with a different truck and crew than performing waste collection)

- Multimaterial simultaneous collection (collection of more than one material combined with waste collection activities)
- Newspaper separate collection
- Newspaper simultaneous collection
- Recycling centers.

In terms of handling functions, Exhibit 25 portrays the five separation scenarios.

After review of available data and consultation with EPA, a goal of twenty-five site visits was established. The visits were apportioned in the following manner:

SYSTEM	NUMBER
Multimaterial, separate, and multimaterial, simultaneous	15
Newsprint, simultaneous	2-3
Newsprint, separate	2-3
Recycling centers	4-6
	23-27

We decided to concentrate on multimaterial and newsprint collection programs because information from previous EPA projects existed describing collection equipment used in newsprint recycling programs. In addition, recent EPA research indicated an increasing municipal interest in multimaterial collection programs.

By applying the broad allocation formula to the list of potential communities, we selected twenty-eight programs for data collection site visits. Two additional communities were chosen to allow for testing of the data forms. Six intermediate processing companies and seven equipment manufacturers located near the designated communities were selected for similar interviews. Exhibit 26 is a list of chosen programs, processors, and manufacturers visited.

The selection criteria were transformed into two interview guides (Exhibits 27 and 28). Since two hundred-plus programs and equipment manufacturers were located through

SOURCE SEPARATION SYSTEMS

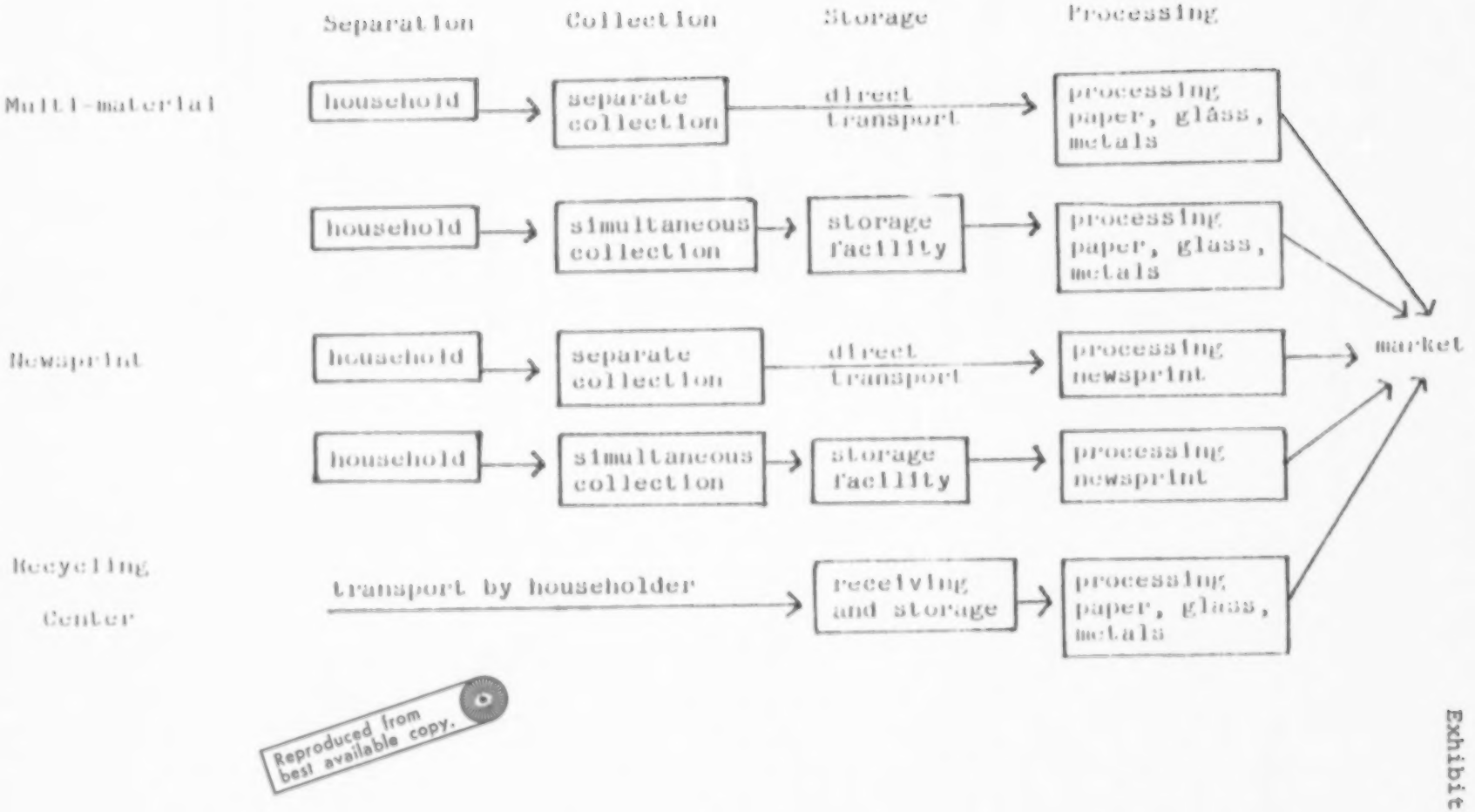

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Exhibit 25

Exhibit 26

Sites Visited

PROGRAMS

Boca Raton, FL
Deerfield Beach, FL
Santa Rosa, CA
El Cerrito, CA
Downey, CA
Davis, CA
Modesto, CA
San Francisco, CA
Boulder, CO
Seattle, WA (Test)
Temple Terrace, FL
Newington, CT
Larchmont, NY
Mamaroneck, NY
Garden City, NY
Carmel, NY
Racine, WI
Madison, WI
University City, MO
East Hartford, CT
East Lyme, CT
West Orange, NJ
Newton, MA
Grand Rapids, MI
Wellesley, MA
Enfield, CT
Lexington, MA
Greenbelt, MD (Test)
Nottingham, NH
Tenafly, NJ

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EQUIPMENT MANUFACTURERS

Miller Manufacturing,
Turlock, CA
Midway Fishing Tool,
Bakersfield, CA
CP Manufacturing,
National City, CA
J.A. Freeman and Sons,
Portland, OR
Northern Truck and Equipment
East Hartford, CT
Connecticut Truck & Trailer
East Hartford, CT
Neilson Iron Works
Racine, WI

INTERMEDIATE PROCESSORS

MATCON
Salem, MA
North Shore Recycled Fibers
Salem, MA
Durbin Paper Co.
Pompano Beach, FL
Recycling Enterprises,
Oxford, MA
Sessler, Inc., Norwalk, CA
Resource Recovery Systems,
Branford, CT

Exhibit 27

INTERVIEW GUIDE FOR COMMUNITIES

LOCATION:
CONTACT:
TELEPHONE:
DATE:
ADDRESS:

1. What materials are collected?
2. How many tons of materials are collected per month?
3. Who sponsors the program?
4. Who has responsibility for collection?
5. How many residents are there in the collection area?
6. What is the frequency of collection?
7. What is the collection method?
8. What equipment is used for collection?
9. Describe the system from household separation to material markets, concentrating on the equipment used in each phase.
10. Who manufactures the equipment you use?

Exhibit 28

INTERVIEW GUIDE FOR EQUIPMENT MANUFACTURERS

LOCATION:
CONTACT:
TELEPHONE:
DATE:
ADDRESS:

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1. What is the cost of the equipment?

2. Can the equipment be purchased "off-the-shelf" or are custom orders required?

3. What is the expected throughput of the equipment per hour, per labor hour, and per capital and operating cost?

4. For what applications may the equipment be used?

5. What is the average maintenance cost of the equipment?

6. What is the manpower needed for operation of the equipment?

7. What are the dimensions of the equipment?

8. What is the weight of the equipment?

9. For a trailer: What is the volume per load?
What is the weight per load?

10. For a separate truck: Describe the truck.
What is the collection volume per load?
What is the collection weight per load?
What is the engine size?
Is optional equipment available?

11. For bin collection: What is the collection volume/load?
What is the collection weight/load?
What is the empty bin weight?
What is the construction material of the bin?

12. For a magnetic separator: What is the separation method?
Is hand-sorting or visual monitoring required?

Is the equipment stationary or mobile?
Describe the equipment configuration.

13. For a can flattener/shredder: What is the method used?
Is hand-sorting or visual monitoring required?
Is the equipment stationary or mobile?
Describe the equipment.
What materials are processed?

14. For a glass crusher: What is the crushing method?
Is hand-sorting or visual monitoring required?
Is the equipment stationary or mobile?
Describe the equipment configuration.

15. For a scale: What are the weight limits?
What type of scale is it (platform, floor level, dial face, arm)?
Describe the equipment utilization.

16. For the conveyance system: Describe the equipment utilization.
Is the unit stationary or mobile?

the search process, the telephone interviews were limited to communities collecting 50 tons or more per month of source-separated materials and manufacturers specializing in sales to recycling collection and processing programs. Exhibit 29 represents the listing of 59 collection programs which were contacted. As revised information was received, additional programs were added to this list (for instance, Deerfield Beach, FL; Seattle, WA; University City, MO; El Cerrito, CA; Santa Rosa, CA; Racine, WI). After the evaluation of initial interview data, twenty-six communities were contacted for further program information (Exhibit 30). The full program information for these programs was carefully reviewed. Using the selection criteria, sixteen programs which were successfully utilizing recycling collection, storage, conveyance, and processing equipment were chosen as the core programs to be visited (programs with asterisks, Exhibit 30).

After discussion with EPA staff, five additional categories of sites were added to the core list, including:

Intermediate processors. The recent growth, particularly in the Northeast, of companies that purchase reclaimable wastes from recycling collection programs, process the material to improve its quality, and sell the products to end users, was evaluated.

Data form testing. Sites in the states of Washington and Maryland were chosen for the testing of the project data collection forms (see below).

Proximate program sites. While the initial group of programs contained a wide variety of equipment, a handful of second-choice programs located nearby were added to expand the data base.

Proximate manufacturers. Manufacturers specializing in equipment sales to recycling groups which were located near the selected programs were chosen for interviews.

The result of the equipment identification and selection process was the designation of the programs, processors, and manufacturers listed in Exhibit 26.

COMMUNITIES COLLECTING 50 TONS OR MORE
OF SOURCE-SEPARATED MATERIALS PER MONTH

Exhibit 29

Community	Materials	Lbs/Person/ Month	Years in Operation*	Manhours/ Week
MULTIMATERIAL SEPARATE TRUCK				
East Lyme, CT	Mixed Paper, Glass, Cans	13.3	6	120
Waltham, MA	Mixed Paper, Glass, Cans	9.17	2-1/2	240
Andover, MA	Mixed Paper, Glass, Cans	10.1	5	N/A
Newton, MA**	Newspaper, Glass, Cans	4.0	6	N/A
Marblehead, MA**	Mixed Paper, Glass, Cans	15.63	6	180
Hartford, CT	Newspaper, Metal Cans	.83	5	240
Waterbury, CT	Cans, Glass	4.73	2-1/2	840
Summit, NJ	Mixed Paper, Glass	6.18	5	N/A
Greenbelt, MD	Newspaper, Aluminum Cans	21.6	7	48
Abington, PA	Newspaper, Glass	12.8	5	44
Rockville, MD	Newspaper, Metal Cans	5.14	6-1/2	30
Boulder, CO	Mixed Paper, Glass	1.65	1-1/2	66
Downey, CA	Newspaper, Glass, Cans	4.1	4	N/A
MULTIMATERIAL TRAILER				
Davis, CA	Newspaper, Glass, Cans	7.33	4	60
MULTIMATERIAL -- EQUIPMENT UNKNOWN				
Newington, CT	Newspaper, Glass	4.78	4	N/A

* As of 1978.

** Use compartmentalized vehicles

COMMUNITIES COLLECTING 50 TONS OR MORE
OF SOURCE-SEPARATED MATERIALS PER MONTH

Exhibit 29 (Cont'd)

Community	Lbs/Person/ Month	Years in Operation*	Manhours/ Week
NEWSPRINT SEPARATE TRUCK			
Peabody, MA	2.04	3	120
W. Hartford, CT	5.71	7	160
Ramapo, NY	1.25	7	20
W. Hempstead, NY	6.67	7	200
Garden City, NY	5.6	5	40
Rockville Centre, NY	4.28	7	54
Ridgewood, NJ	3.33	5	54 - collection 5 - processing
Clifton, NJ	2.47	4	48
Bergenfield, NJ	3.09	4-1/2	13
Paramus, NJ	5.0	3	8
W. Orange, NJ	7.67	4-1/2	156
Montclair, NJ		3-1/2	35 - collection 4 - processing
Teaneck, NJ	5.71		35
Alexandria, VA	3.24	5	12
Boca Raton, FL	10.31	4	240
Lexington, KY	.45	4	75
Shorewood, WI	8.0	8	12
El Paso, TX	.57	4	262
Dallas, TX		6	280
University City, MO	8.33	6-1/2	75
Santa Barbara, CA	1.12	4	
Berkeley, CA	1.25	5	60
Newport Beach, CA	3.07	4	104
Modesto, CA	4.45	5	180
San Diego, CA	.70	4	
NEWSPRINT RACK			
Salt Lake City, UT	1.88	4	
Rockford, IL	.846	4-1/2	714
Madison, WI	1.87	8	
Tucson, AZ	.57	2	1-1/4
Sacramento County, CA	.74	2-1/2	6,400

* As of 1978.

COMMUNITIES COLLECTING 50 TONS OR MORE
OF SOURCE-SEPARATED MATERIALS PER MONTH

Exhibit 29 (Cont'd)

Community	Lbs/Person/ Month	Years in Operation*	Manhours/ Week
NEWSPRINT TRAILER			
Garland, TX	1.54	3-1/2	520
E. Hartford, CT	1.83	6	760
Enfield, CT	3.75		600
MIXED PAPER SEPARATE TRUCK			
Greenwich, CT	2.58	2-1/2	110
Norwalk, CT	1.25	5	
Ossining, NY (town)	4.35	4	32
Yonkers, NY	.5	4	
Carmel, NY	6.15	5-1/2	70
Mamaroneck, NY	5.26	7	50
Mamaroneck-Larchmont, NY	13.0	5	80-100 collection 24-30 processing
University Park, TX	8.33	6-1/2	75
MIXED PAPER RACK			
Stamford, CT	1.82	3	210
San Francisco, CA	3.2	25	
MIXED PAPER TRAILER			
Bloomfield, NJ	5.0	3	8

* As of 1978.

Exhibit 30

COMMUNITIES CONTACTED CONCERNING SITE VISITS

Summit, NJ
Abington, PA
* Boulder, CO
* Downey, CA
* Davis, CA
* Modesto, CA
* El Cerito, CA
* Newington, CN
Andover, MA
Waltham, MA
Waterbury, CN
* East Lyme, CN
* West Orange, NJ
* Boca Raton, FL

Shorewood, WI
West Hartford, CN
* Garden City, NY
* San Francisco, CA
Salt Lake City, UT
Tucson, AZ
Ossining, NY
* Carmel, NY
* Mamaroneck, NY
* Larchmont-Mamaroneck, NY
* Enfield, CN
* East Hartford, CN

* Sites Visited

To acquire data about the use of each type of recycling equipment, thirteen sets of data forms were developed, including:

- Program information
- Household separation unit
- Truck
- Trailer
- Collection bin
- Recycling facility
- Magnetic separator
- Can flattener/separator
- Scale
- Crusher
- Storage and processing containers
- Conveyance system
- Bailer.

Before site visits were initiated, two tasks were completed to assure the quality of data collection systems. First, the data forms were tested in visits to Greenbelt, Maryland and Seattle, Washington (Seattle Recycling, Inc.). The completed forms and the data collection process were analyzed and critiqued. The forms were then revised to clarify, add, or eliminate certain questions. Secondly, a manual was prepared for use by the project researchers to assure the uniformity of the data collection effort. A sample set of data forms for collection bins is provided as Exhibit 31.

Contact was initiated with the appropriate program officials and equipment manufacturers. An explanation of the project objectives and a complete set of data forms were provided to the program managers before site visits were undertaken. Employing a project interview guide and the data form manual, research staff visited each site. Between December 1978 and July 1979, interviews were conducted, program information and materials acquired, equipment surveyed, and photographs taken. Second site visits,

[redacted]: _____ [redacted] PAGE ONE OF 4

INTERVIEW

		Additional Comments
1. The bins are used in a	multi-material program _____ single item program _____	
2. The bins are utilized on a	truck only _____ truck and trailer ____	
3. Are specific bins used for specific materials; if so, please describe		
4. Are there special requirements for fork-lift use in utilizing the bins		Does the program use a rotating head or tilting forklift truck?
5. Are there route problems with any or all of the following	one bin filling up faster than others _____ bin height creating loading problems _____ lack of bin covers leading to contamination problems _____ littering and blow-off _____ other _____	
6. Maximum bin volume per load is		
7. Maximum bin weight per load is	_____pounds of glass _____pounds of metals _____pounds of paper _____pounds of other recyclables	
8. the empty bin weight is		
9. How long have you utilized this bin system		
10. Please describe the design considerations for the development of this system		
11. What is the average volume collected in one trip		

Exhibit 31

INTERVIEW (cont)

		Additional Comments
12. What is the average weight collected in one trip		
13. Have you modified the bins	no ____ yes ____ type of modification :	
14. Please describe the procurement of the bins : were the bins readily available from a manufacturer are they standard waste collection equipment did you construct the bins in your shop or significantly modify existing equipment what was the procurement lead-time please describe the financing arrangements for bin purchase		
15. What were the bin costs	purchase or fabrication ____ delivery ____ modification ____ maintenance ____	
16. The supplier or manufacturer was	name : contact :	

MEASUREMENT

1. Bin Description dimensions	height ____ length ____ width ____	
cubic volume		
are they divided or partitioned; if so, in what manner		

Exhibit 31 (Cont'd)

AG ORE F

MEASUREMENT (cont.)

1.(cont.)

do the bins include lids or covers

bins are constructed of
- wood _____
- metal _____
- fiberglass ____
- gauge _____
- other _____

if self-dumping bin:
- on pivot _____
- angled floor _____
- use of tilting fork _____

height from street to bin top
- for use on truck _____
- for use on trailer _____

Additional Comments

2. Bin Performance

method of bin removal
- fork-lift _____
- roll-off _____
- other _____

method of securing bins
- tie-downs _____
- pins _____
- other _____

can bins be used for more than one material

are bins used for
- processing functions _____
- storage _____
- marketing functions _____

houses collected per day

crew size (includes driver) (please note if driver performs collection duties)
- one-man _____
- two-man _____
- three-man _____

description of on-route procedures in terms of bin use

Exhibit 31 (Cont'd)

[redacted] NUMBER [redacted] PROGRAM OFFICER [redacted] SITE CONTACT [redacted]
DATE: _____ PAGE FOUR OF 4

MEASUREMENT (cont.)

3. Design Considerations:
   ease of repair and up-keep

   capacity to retrofit

4. Photographs Roll # _____
                Shot # _____

Additional Comments

Exhibit 31 (Cont'd)

follow-up telephone interviews, and research correspondence were required for several communities.

Upon completion of our research, we prepared a detailed outline of the guide. In order that the research and analysis meet the needs of the EPA and the potential equipment user, a committee of municipal source-separation collection program officials, equipment manufacturers, intermediate processors, EPA staff, and solid waste management association representatives were selected to review the draft outline. A meeting of the committee was held in Washington, D.C. on June 21, 1979. The comments and recommendations of committee members were incorporated into the revised guide outline. In addition, committee members reviewed and critiqued the draft user's guide before final editing. The research staff appreciated the participation of the committee; their advice improved the quality of the user's manual.

Appendix B

RECOMMENDATIONS FOR PROCUREMENT OF SOURCE-SEPARATION COLLECTION AND PROCESSING EQUIPMENT

The development of a source-separation program generally follows a set of specific steps, from planning to procurement to operation (Exhibit 32). While many program officials have undertaken similar planning activities, the procurement of recycling collection and processing equipment varies by community.

The laws and procedures which govern local government procurement of equipment vary widely among jurisdictions. The municipalities and private firms which were visited as part of this research effort utilized various procurement systems, which can be broadly categorized by two methods. Where cost is the important criterion, a traditional advertising procurement system is used. Definitive design or performance specifications are used to develop an Invitation to Bid. After formal advertising, bids are sought and received from manufacturers or suppliers of recycling equipment. The bids are evaluated on cost and technical merit with the award going to the best and lowest bidder.

When the buyer seeks to acquire a full system such as a processing line, a competitive negotiation method may be used. Rather than requesting specific bids, the municipality or recycling firm issues a Request for Proposal. After a thorough evaluation of the proposer's documents, a negotiation process is initiated with one or more bidders.

Not only did the procurement methods used in the surveyed programs differ greatly, the use of various procurement options was noted. While the most common strategy was to purchase recycling equipment as delivered, several programs used other options. For instance, one private program operator purchased an aluminum processing system on a turn-key basis with the equipment supplier undertaking

Source Separation Program Development

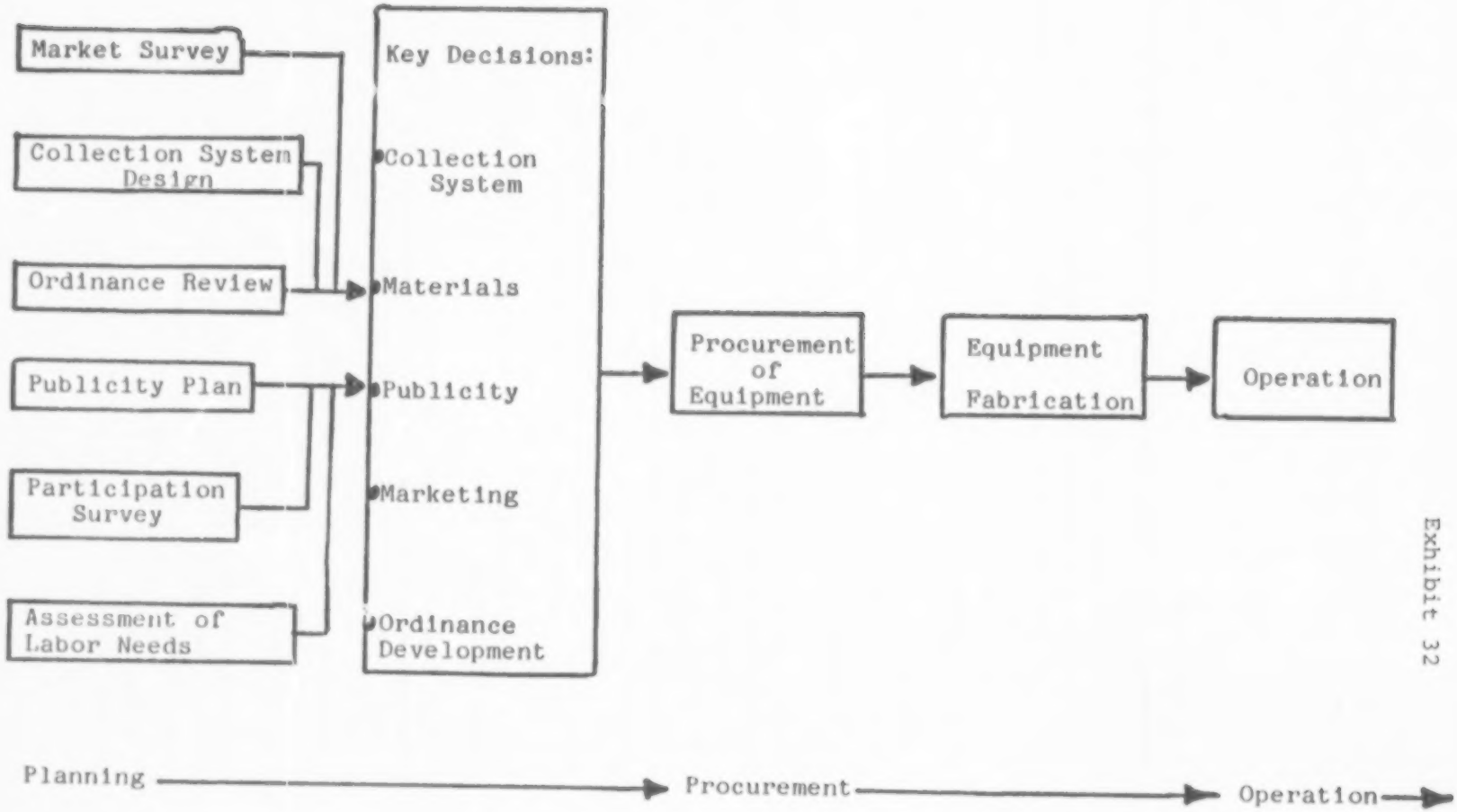


Exhibit 32

site design, construction, and start-up activities in addition to equipment delivery. In another community, the recycling program official had entered into negotiations with a supplier for a full-service contract. Under this option, the equipment user is provided the equipment, installation, site construction, and equipment maintenance for one price.

The proper use of sound procurement procedures is essential in the development of a source-separation system. The following sections include recommendations for procurement for four audiences:

- Municipalities
- Private sanitation companies
- Equipment manufacturers
- Equipment suppliers.

Municipalities

In order to protect the public interest, municipalities have instituted procurement systems that seem complex and cumbersome in comparison to those employed by private industry. In particular, many municipalities have attempted to procure source-separation collection and processing equipment by using standard bidding systems. Unfortunately, there is not a multitude of manufacturers from which a municipality can choose.

One crucial barrier to municipal procurement of recycling equipment has been the inappropriate use of specifications. Specifications are lists of the essential characteristics that municipalities submit to bidders to describe the equipment. They may include:

- Brand names
- List of qualified products or brands
- Design specifications
- Performance specifications
- Costs of operation.

The use of design and performance specifications has created problems in some communities purchasing recycling equipment. To avoid problems, municipalities should:

- Refrain from using design specifications provided by equipment suppliers
- Avoid using numerous specifications, thereby restricting the number of bidders
- Use enough specifications to be able to evaluate bids
- Avoid using overly restrictive or proprietary specifications that limit competition.

In addition to assisting municipalities in the development of specifications, municipal officials should do the following:

- Trade in excess equipment, if possible, when purchasing new equipment. Most equipment suppliers have developed networks of users in their service areas and can offer a better bid for used equipment than municipalities could find on their own.
- Lease equipment, when appropriate. One of the more successful separate truck collection programs (Boca Raton, Florida) has leased vehicles to minimize start-up costs, shorten the procurement lead-time, and allow for program growth and flexibility.
- Carefully select ironworks and equipment companies to maintain and upgrade recycling equipment, if the municipality does not possess a full-service municipal shop.
- Consult with recycling program employees when developing design and performance specfications. The crews involved in on-route service or material processing can provide a wealth of knowledge regarding optimization of program equipment.
- Ask a safety consultant or a safety officer to examine proposed bid packages and to test delivered equipment. As suggested in the previous chapters, recycling equipment safety standards have been relatively lax in comparison to those of waste collection equipment. Municipalities should increase their effort to assure the procurement of recycling equipment which is safe to use.

- Visit other sites. The use of particular equipment systems in certain communities should be carefully reviewed for application to other communities. For instance, Enfield, Connecticut was able to acquire trainer information from municipal officials in East Hartford, Connecticut. In another example, El Cerrito, California, officials designed their collection system after receiving on-site assistance from program operators in Modesto, California. The U.S. EPA-sponsored Peer Match Program may be a tool for use by municipalities. This program provides municipal employees an opportunity to visit other communities which have undertaken specific solid waste management.

- Request EPA technical assistance. The U.S. EPA has contracted with planning and engineering firms in each federal region to provide assistance to municipal solid waste management agencies. This program can be a useful tool for decision-makers to receive assistance in equipment selection and design.

Private Sanitation Companies and Recycling Agencies

From the research findings we can conclude that private organizations involved in recycling collection procure their equipment by methods different from those of municipal recycling programs. Among the features of private procurement are:

- A tendency to fabricate the equipment on-site, using company resources. Other than the construction of racks, municipalities tend to seek bids for truck, trailer, and processing units.

- On the other hand, private operators seem willing to fabricate their equipment. For instance, the trailer system used in Davis, California, was developed at the hauler's truck repair yard. The private operator in Modesto, California, constructed the trailers and roll-off containers used in the recycling program.

- A higher likelihood of being offered and receiving payment discounts or financing options. As smaller private firms can issue payments on a prompt schedule, discounts from 1-3 percent on payments within 30 days were reported. In addition, several equipment manufacturers reported that they only offer financing alternatives to private firms and not to municipal buyers.

- Use of equipment resale value as a procurement variable. While life-cycle costing methods are being used by a growing number of municipalities, the traditional evaluation criterion remains the unit cost at the front end. On the other hand, private operators in Santa Rosa and Modesto, California, and in Seattle, Washington, stated that the equipment value after use was an important factor in selecting suppliers and manufacturers.

- Use of a simpler procurement system. Few private operators described procurement methods similar to those employed by municipalities. Bidder lists were not maintained; advertisements were generally not issued; and the evaluation process appeared to be subjective. For instance, the procurement of household separation units and metals processing equipment in Seattle was undertaken after only two bids for each were sought and received.

- Greater tendency to not select the lowest bidder. The broad procurement goal of selecting the lowest and best bid results in the private operator's willingness to pay an additional amount of funds to procure a better unit.

- Shorter procurement lead-time. Exhibit 33 provides a summary of the lead-time for recycling equipment procurement. Due to the willingness and ease of private firms in designing equipment, selecting among bidders, and due to the use of a simple procurement method, private recycling companies can quickly acquire equipment.

As noted in the National Science Foundation-sponsored research undertaken in the past years by Columbia University, many municipalities are seriously considering a shift from municipal to private waste collection. At the same time, many communities are evaluating the merits of source-separation systems. It is therefore very likely that the number of private sanitation firms providing recycling collection service will increase. In order for these firms to develop quality source-separation collection systems, their procurement practices should incorporate the following:

- Consult with program employees when developing design, performance, or modification specifications.

Exhibit 33

PROCUREMENT LEAD-TIME

I. Household Separation Units

Community	Operator	Type	Lead-Time
Santa Rosa	private	cart/pan	3 months
El Cerrito	private	bucket	2 months
Seattle	private	bag	1 month
University City	municipal	bin	8 months

II. Trucks

Community	Operator	Type	Lead-Time
Deerfield Beach	municipal	compactor	5 months
Garden City	"	"	3 months
East Lyme	"	"	9 months
Newton	"	compartmentalized	3 mths
Modesto	private	pick-up	1.5 months
Davis	"	"	.25 months
Seattle	"	flat-bed	1 month
Downey	"	dump-bed	2 month
Santa Rosa	"	R.V. chassis	1 month

III. Trailers

Community/manufacturer	Operator	Type	Lead-time
East Hartford	municipal	dump	6 months
Temple Terrace	"	multi-material	1 month
Seattle	private	for bins	1 month
Modesto	"	"	2 months
Davis	"	multi-material	2.5 months
Northern Truck	manufacturer	dump	1-1.5 months

IV. Collection Bins

Community	Operator	Lead time
Boca Raton	municipal	.25 month
Seattle	private	4 months
Santa Rosa	private	3 months
El Cerrito	private	3 months

V. Racks

Community	Operator	Type	Lead-Time (1)
Racine	municipal	side	3 months
Madison	"	"	.05 month
Temple Terrace	"	"	1 month
Temple Terrace	"	rear	.75 month
Newington	"	side	.05 month

(1) including design

VI. Storage Equipment

Community	Operator	Type	Lead-Time
Davis	private	Roll-off	.25 month
Modesto	private	"	1.5 month
Wellesley	municipal	"	2-3 months

VII. Conveyance

Community	Operator	Type	Lead-Time
Modesto	private	Fork-lift	.25 month
Seattle	private	"	.25 month

VIII. Processing Equipment

Community/manufacturer	Operator	Type	Lead-Time
El Cerrito	private	magnetic sep.	1 month
Seattle	"	"	1.5 month
Modesto	"	"	1 month
Miller Manufacturing	manufacturer	"	1-3 month
Miller Manufacturing	manufacturer	shredder	3 month
Dry Bulk Engineering	"	shredder	3.5 month
Seattle	private	flattener	1.5 month
Modesto	"	baler	.25 month
Wellesley	"	baler	2. month
Freeman and Sons	manufacturer	baler	.5 month
Seattle	private	scale	.5 month
Wellesley	municipal	"	2 month

- Use a safety consultant to assure the procurement of safe equipment.
- Visit other sites. The regional office of the U.S. EPA can provide the location and contact person for successful programs in the area.

Equipment Manufacturers

Most equipment manufacturers do not perceive the recycling collection marketplace as large. As a general rule, few companies have developed equipment specifically for source-separation collection programs. For instance, the metals processing equipment that was reviewed for this study was manufactured for the aluminum processing industry. Additionally, we did not locate any waste manufacturers or truck suppliers who advertised the availability of racks as an equipment option.

For the special manufacturers who were interviewed, several marketing techniques were described, including:

- Use of firm quotes. Most manufacturers offered price quotations on a thirty-day firm basis, although one processing equipment fabricator provided firm quotes of one year's length.
- Use of service options. Several specialty manufacturers provide user assistance, including:
  - -- on-site visits during installation or start-up
  - -- resale service for older equipment
  - -- use of turn-key systems.
- Use of experience ratings in place of rated capacity. Several processing equipment manufacturers were reluctant to offer a statement of rated capacity due to variations in use created by power drops, the material mix, the size of units to be processed, and the material in-feed system.

Recommendations for enhanced marketing by equipment manufacturers are:

- Brochures, bid packages, and sales materials should be developed to specifically address the source-separation collection and processing equipment user.

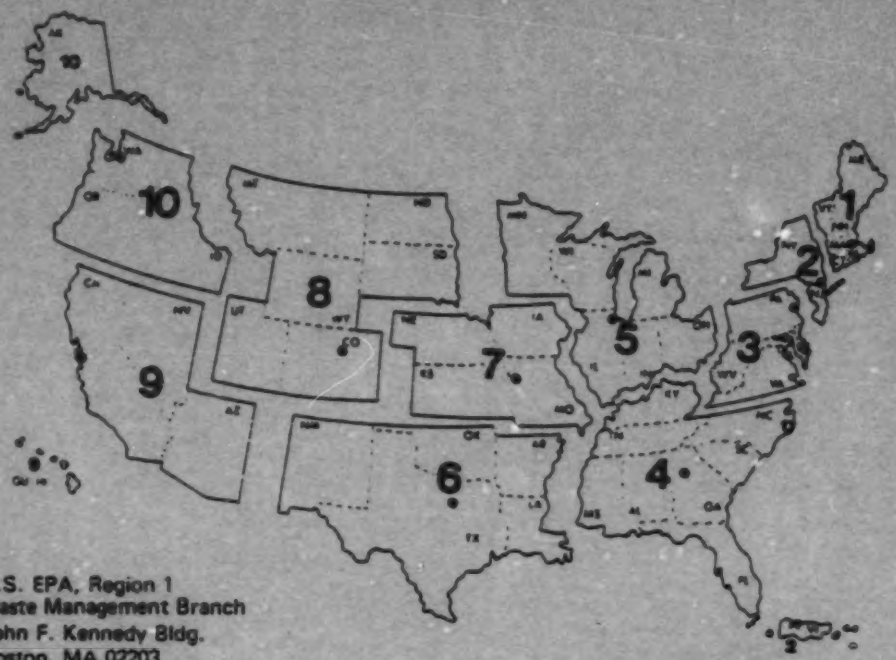
- These materials should incorporate current procurement concepts such as life-cycle costing.
- Manufacturers of processing equipment should be encouraged to develop turn-key sales systems. Many potential buyers of processing equipment desire a total procurement package, including equipment installation, shakedown, and employee training.
- The Waste Equipment Manufacturers Institute (WEMI) might develop a recycling equipment manufacturers committee. As the trade organization which "provides technical information to manufacturers and users of waste handling and resource recovery equipment," WEMI is logically the association which can provide industry leadership in expanding the marketing opportunities for manufacturers of recycling equipment.
- Equipment research and development efforts should be expanded. As many communities are seeking to efficiently collect and process materials, new equipment applications should be presented. For instance, the development and use of a multimaterial collection vehicle by LoDal, Inc., in Santa Rosa, California, should be noted by the other major waste compactor manufacturers.

Equipment Suppliers

As a broad rule, few manufacturers specializing in equipment for the recycling industry use a distributor network. The exception to this is the marketing of balers. Equipment is generally sold by the manufacturer on a regional basis. On the other hand, some manufacturers of the more expensive equipment such as shredders use distributors to service distant areas.

The recommendations offered for equipment manufacturers also pertain to equipment suppliers. In addition, it is recommended that equipment suppliers maintain contact with the various associations of recycling program operators. For instance, the California Resource Recovery Association represents more than 400 waste haulers, municipalities, and recycling organizations.

EPA REGIONS



U.S. EPA, Region 1
Waste Management Branch
John F. Kennedy Bldg.
Boston, MA 02203
617-223-5775

U.S. EPA, Region 2
Solid Waste Branch
26 Federal Plaza
New York, NY 10007
212-264-0503

U.S. EPA, Region 3
Hazardous Materials Branch
6th and Walnut Sts.
Philadelphia, PA 19106
215-597-7370

U.S. EPA, Region 4
Residuals Management Br.
345 Courtland St., N.E.
Atlanta, GA 30365
404-881-3016

U.S. EPA, Region 5
Waste Management Branch
230 South Dearborn St.
Chicago, IL 60604
312-353-2197

U.S. EPA, Region 6
Solid Waste Branch
1201 Elm St.
Dallas, TX 75270
214-767-2645

U.S. EPA, Region 7
Hazardous Materials Branch
324 East 11th St.
Kansas City, MO 64106
816-374-3307

U.S. EPA, Region 8
Waste Management Branch
1860 Lincoln St.
Denver, CO 80295
303-837-2221

U.S. EPA, Region 9
Hazardous Materials Branch
215 Fremont St.
San Francisco, CA 94105
415-556-4606

U.S. EPA, Region 10
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1200 6th Ave.
Seattle, WA 98101
206-442-1260

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